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TECHNICAL REPORT RD–ST–95–14

FLEX WING FABRICATION AND STATIC PRESSURE TESTING

Larry D. Lucas
Structures Directorate
Research, Development, and Engineering Center

June 1995

U. S. ARMY MISSILE COMMAND

Redstone Arsenal, Alabama 35898-5000

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This report documents the fabrication of flex wings in a manufacturing summary and experimental tests performed with a static pressure loading apparatus. The purpose of the static pressure tests were to simulate a typical aerodynamic pressure loading applied to the flex wing. A pressure loading was applied to the flex wing until failure occurred. The maximum normal force and root bending moment were calculated to predict the performance of the flex wing. Test results indicated a maximum root bending moment of 205 and 246 in-lbs for the .012 and .016 inch wings, respectively. These results compared well with previous studies. The results of the static pressure tests will be used to verify the finite element model [1] and build the flex wing data base. It is recommended that the effects of collapse and stowage deformations on the flex wing flight load performance be further studied.

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I. INTRODUCTION

This report documents the effort on the development of The Army Combined Arms Weapon System (TACAWS) flex wing analysis and design. The effort presented herein is follow–on to the work documented in the technical report titled, "Flex Wing Finite Element Analysis and Design for The Army Combined Arms Weapon System" [1].

A contract to fabricate several flex wings was delivered. Experimental tests were performed on the flex wings to determine the load capability of the flex wing. Test results indicated a maximum root bending moment of 205 and 246 in–lbs for the .012 and .016 inch wings, respectively. A 10 g maneuver from TACAWS imparts a root bending moment of 376 in–lbs on the flex wings which indicates that the .012 and .016 inch wings may fail in a 5.4 and 6.5 g maneuver, respectively.

The purpose of this effort was to fabricate several flex wings and experimentally determine wing performance. Experimental tests included static pressure, x–ray diffraction, and micro–strain gauge tests. This report focuses on the fabrication and assembly [2] of the flex wings and the static pressure testing. Results of the experimental tests are used to verify the finite element analysis work [1] and build the flex wing data base.

The static pressure tests simulate a typical aerodynamic pressure loading distribution on the flex wing during a missile flight. Static pressure is applied to the flex wing utilizing a special testing apparatus discussed in this report. Pressure is applied to the flex wing and reaction forces are recorded until flex wing failure occurs. The results of the static pressure testing are discussed in Section III. Conclusions are presented in Section IV and a manufacturing summary of the flex wing is included in Appendix C.

II. FABRICATION

A total of six flex wings numbered one through six were delivered in January 1995 under Contract No. DAAH01–94–D–R002, Mesa Associates, Inc., Madison, AL. The flex wings numbered one through three have a skin thickness of .016 inches, and the other wings numbered four through six have a .012 inch skin thickness. Photographs of flex wing number three are shown in Figures 1 and 2.

Figure 1. Fabricated Flex Wing, Side View

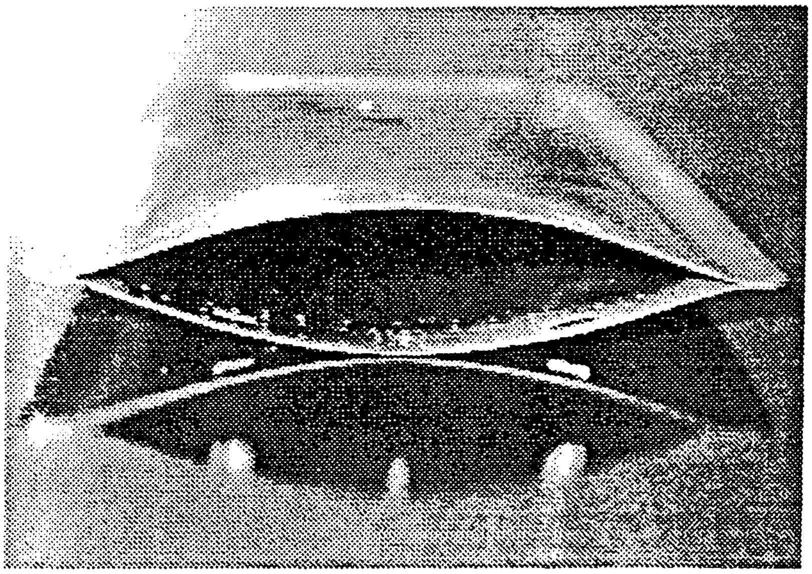

Figure 2. Fabricated Flex Wing, Bottom View

The flex wings were fabricated and assembled by Campbell Engineering, Inc., Huntsville, AL. A Manufacturing Summary Report is presented as Appendix C. Drawings of the flex wing, wing attachment clips, and weld fixtures are located in the manufacturing summary along with weld schedules, weld pull tests, and tensile test results.

The fabrication and assembly process discussed in the manufacturing summary is very similar to the process described by the Jet Propulsion Laboratory (JPL) in previous flex wing studies [3]. First, the flex wing halves are formed into their initial concave shapes. Next, the wing halves are heat treated (condition TH1050 per MIL–H–6875) after the stiffeners and wing halves are welded together. Lastly, the wing halves are placed in a welding fixture shown in Figure 3, welded together, released, and trimmed to the final form illustrated in Figure 1.

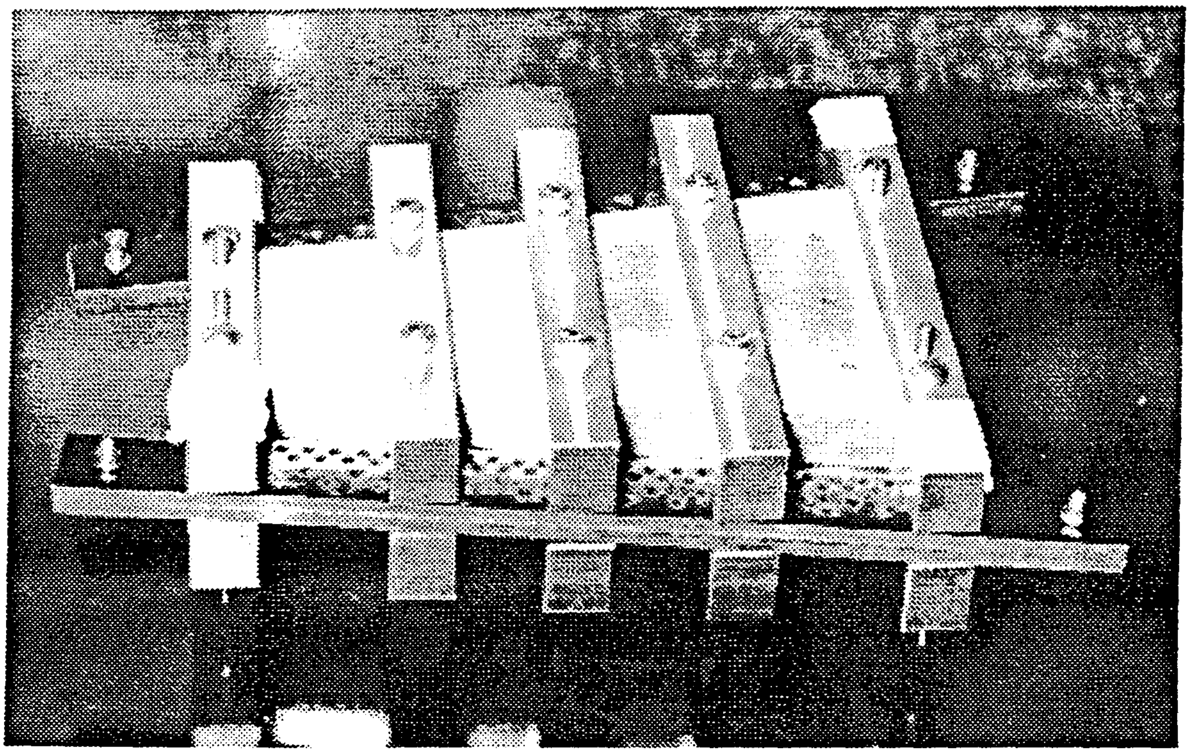

Figure 3. Flex Wing Welding Fixture

III. STATIC PRESSURE TESTING

This chapter discusses the test fixture hardware, instrumentation, test set–up, testing procedures, and root bending moment calculations. The flex wing static pressure tests were performed in the Actuation Systems Laboratory, Missile Guidance Directorate, Building 5475. The test set–up and testing procedures were assisted by Mr. Don Hall, Actuation Systems Laboratory.

A. Test Fixture and Instrumentation

The pressure testing apparatus shown in Figure 4 was designed and fabricated by JPL in the late 1980's. The test fixture was acquired and refurbished by the Structural Analysis and Design Function, MICOM, in 1994. Drawings of the refurbished parts are contained in Appendix D. This fixture was used to perform static pressure tests on the flex wing.

The test fixture consists of a balance beam and a pressure vessel with a rubber bladder. Nitrogen gas supplied to the pressure vessel expands the rubber bladder so that it makes contact with one side of the flex wing. The rubber bladder applies a constant static pressure loading to the flex wing skin. The balance beam is constrained at one end with a flexible joint adjacent to the base of the wing, which allows the beam to freely translate in the horizontal direction and rotate freely about a horizontal axis. It is constrained at the other end with load cells so that normal forces and root bending moments may be calculated. There is also a gas line routed through the base of the flex wing that supplies internal pressure to the wing. The resultant of the external pressure and internal pressure simulate a typical aerodynamic pressure loading distribution.

Pressure testing instrumentation is summarized in Table 1. The ASTRO–Med MT–9500 multitask recorder was used to perform the data acquisition as shown in Figure 5. The MT–9500 produces thermal strip chart printouts with the capability of recording eight channels at 200 KHz sample rate. Five channels were utilized to record the instrumentation output summarized in Table 1. Channels one and two were conditioned with an amplifier signal conditioner ASC–906, DC bridge amplifier, 40 Hz filter, scale X100, and dial scale of .1. Channels four and five were conditioned with a high gain amplifier ASC–908, zero suppression dial setting of .6, 40 Hz filter, scale mv/div, and dial scale of 1. Load cell specifications and calibration are contained in Appendix B.

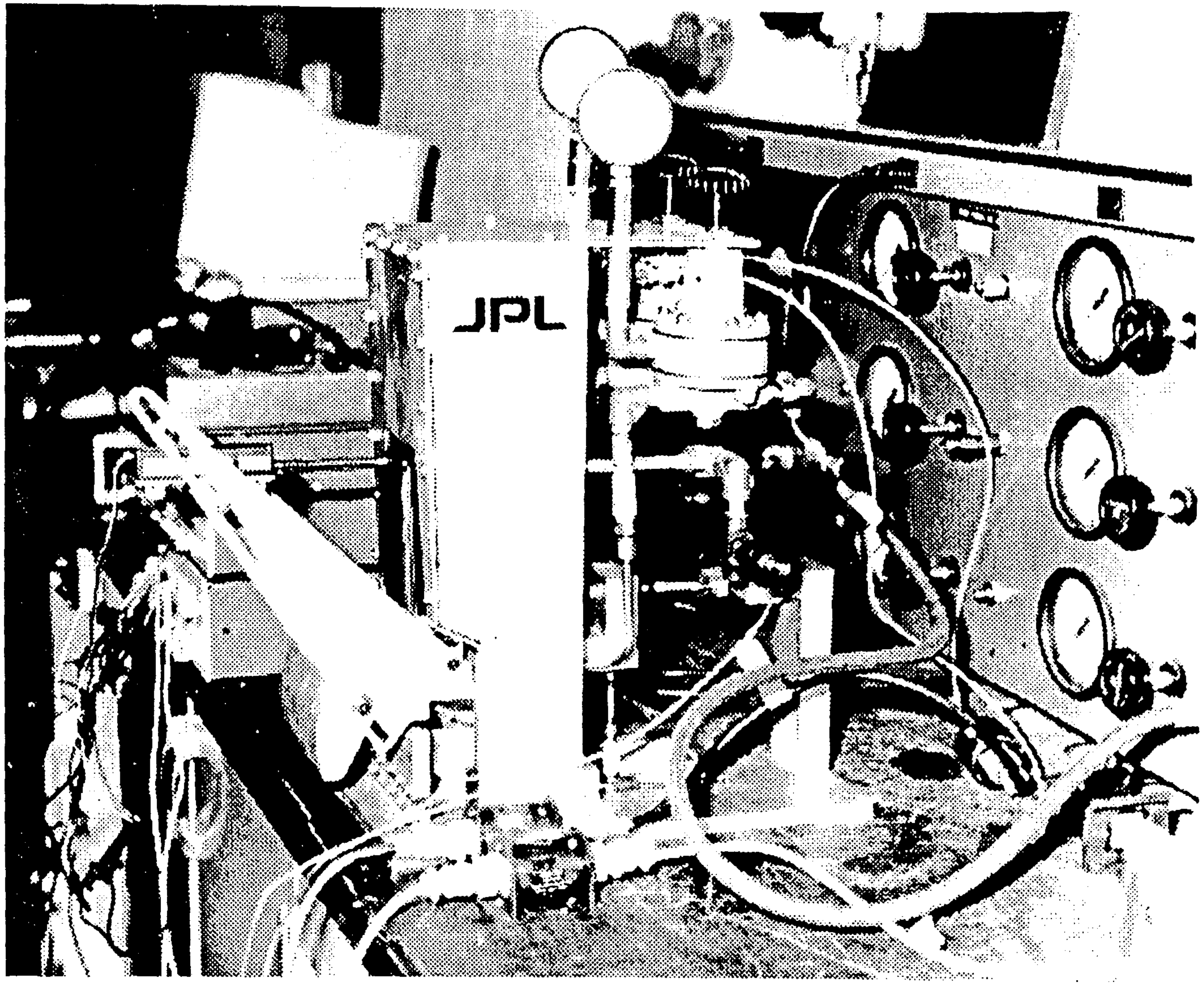

Figure 4. Flex Wing Static Pressure Testing Fixture

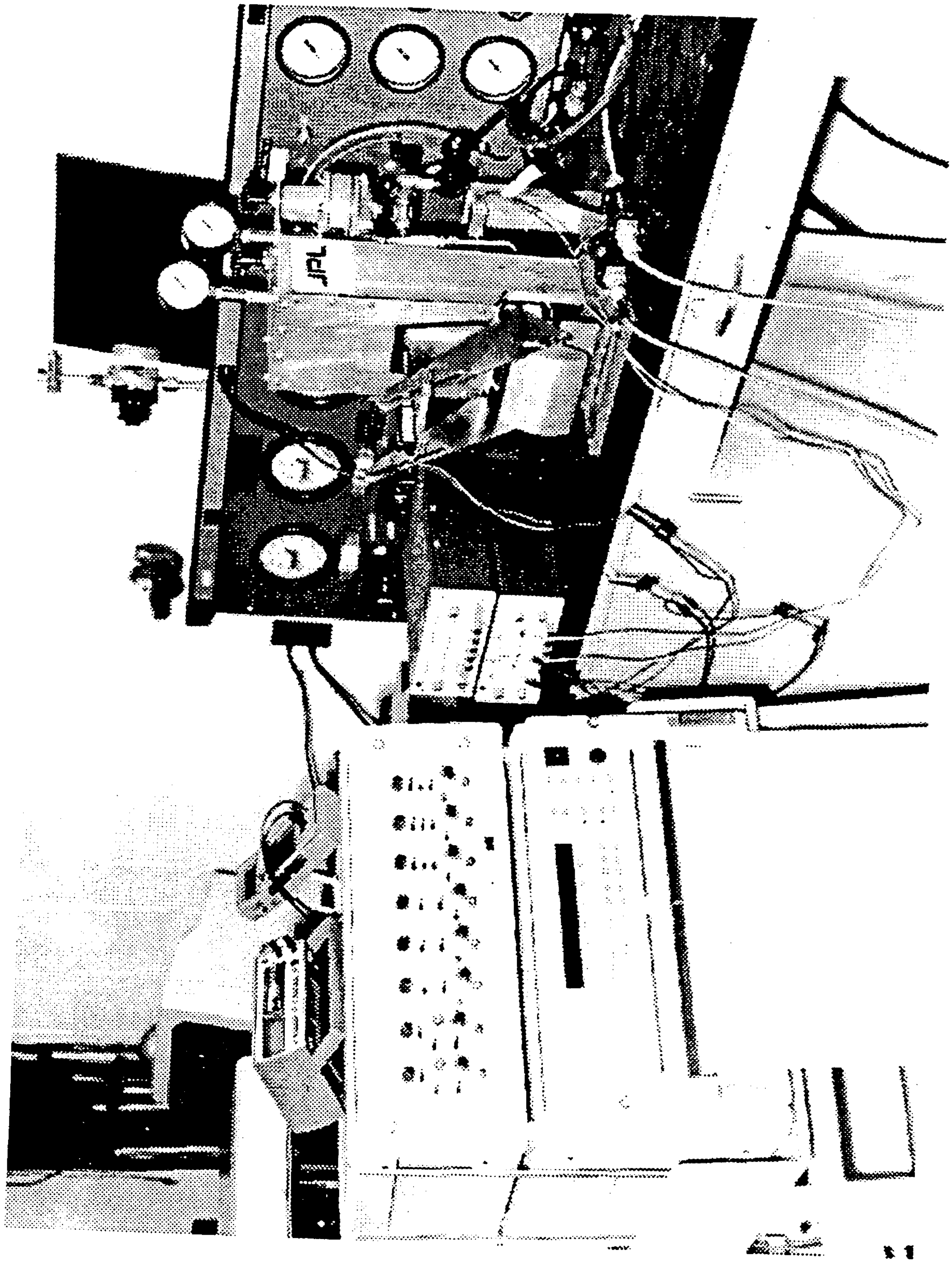

Figure 5. Flex Wing Static Pressure Testing Instrumentation

Table 1. Flex Wing Static Pressure Testing Instrumentation

	CHANNEL	RANGE	EXCITATION VOLTAGE	OUTPUT VOLTAGE	MODEL NO.	SERIAL NO.
EXTERNAL PRESSURE TRANSDUCER	1	0-10 PSI	24	0-5	CD32	21511
INTERNAL PRESSURE TRANSDUCER	2	0-10 PSI	24	0-5	CD32	19722
LINEAR POSITION TRANSDUCER	3	0-.25 INCHES	5	0-5	2.00-202	108257-9
SUPER MINI-BEAM LOAD CELL	4	0-250 LBS	10	0-10	SM-250	C48510
MINI-BEAM LOAD CELL	5	0-250LBS	10	0-10	MB-250	C28181

B. Test Set–Up and Procedures

A total of four flex wings were prepared and tested as described in this section. First, the flex wings were mounted on a special base (Fig. 6) designed for the test fixture. The base has a through hole in the bottom allowing nitrogen gas to provide an internal pressure to the flex wing. The wings were mounted with two wing clips (drawing no. TCW00048, Appendix C); two screws held each of the wing clips in place. Next, a bead of RTV, 100 percent silicon rubber, was applied at the wing root and base to seal this area for the internal pressure. It was noted that it was not necessary to apply RTV internally where the flex wings join together. The base and wing were then attached to the balance beam. Next, the linear position transducer was attached to the balance beam as shown in Figure 4.

Initial readings were checked and the instrumentation was zeroed out as required. The tests were started by slowly pressurizing the rubber bladder (external pressure) and applying internal pressure with hand regulators mounted on the test fixture. It is noted that it was necessary to monitor the output of the pressure transducers with voltage meters to accurately control the applied pressures. In the majority of the tests, the internal pressure was maintained at a level of one–half the external pressure as both pressures were increased. The pressures were increased at rates varying from approximately 3.5 to 12 psi/min. All of the instrumentation outputs were measured and recorded in real time. The tests were continued until the wing collapsed and would not carry any additional loading; defined as buckling failure.

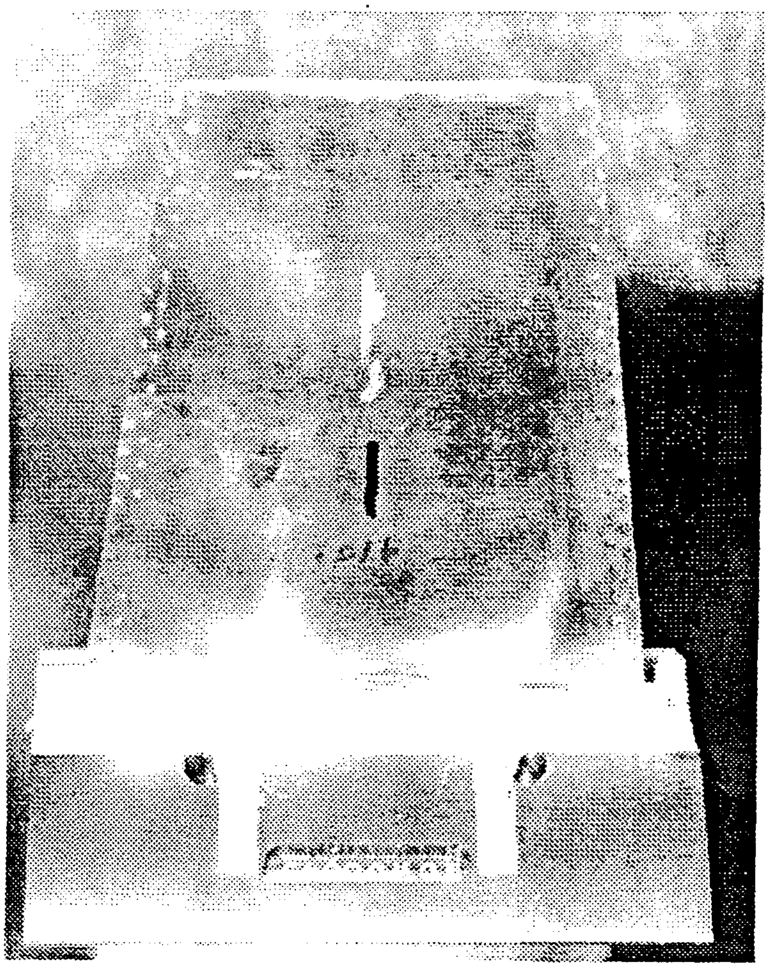

Figure 6. Flex Wing Test Fixture Mounting Base

C. Normal Force and Root Bending Moment Calculations

The normal force and root bending calculations are developed as follows:

$$NF = V_{SM}\ \alpha_{LC}\ \alpha_S,$$

where,

NF = normal force as illustrated in Figure 7
V_{SM} = output voltage of super–mini load cell (mv)
α_{LC} = conversion factor for load cell (lbs/mv)
α_S = spring calibration factor for load (lbs/lbs).

The spring calibration factor was determined by applying a 25 pound calibrated spring force to the balance beam adjacent to the flex wing base. The output voltage of the super–mini load cell was recorded and converted into a force. The spring calibration factor was calculated by dividing the calibrated spring force by the load cell force. The spring calibration factor for the super–mini load cell was 1.19. The minibeam load cell was also checked and the spring calibration factor was equal to 1.0.

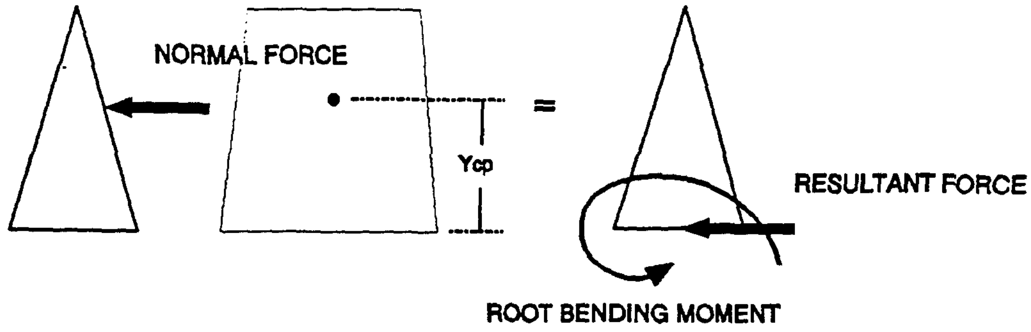

Figure 7. Flex Wing Normal Force and Root Bending Moment

$$\alpha_{LC} = C/(V_{EX}\ \delta),$$

where,

C = capacity of load cell (lbs)
V_{EX} = excitation voltage (volts)
δ = calibration factor for load cell (mv/v).

The following example presents the normal force calculations for a typical test:

α_{LC} = 250 lbs / (10 volts * 3.211 mv/v) ≈ 7.786 lbs/mv,

NF = 10 mv * 7.786 lbs/mv * 1.19 ≈ 93 lbs.

The root bending moment is calculated by the following equation:

$$RBM = V_{MB}\ \alpha_{LC}\ X_{MB} + NF_U\ (Y_{SM} - Y_B),$$

and

$$NF_U = NF / \alpha_S,$$

where,

RBM = root bending moment as illustrated in Figure 7
V_{MB} = output voltage of minibeam load cell (mv)
X_{MB} = horizontal distance from point 0 to minibeam load cell as illustrated in Figure 8
NF_U = normal force uncorrected with the spring calibration factor
Y_{SM} = vertical distance from point 0 to the super–mini load cell
Y_B = vertical distance from point 0 to the base of the flex wing.

The following example presents the root bending moment calculations for a typical test:

α_{LC} = 250 lbs / (10 volts * 3.230 mv/v) ≈ 7.74 lbs/mv,

NF_U = 93 lbs / 1.19 ≈ 78 lbs,

RBM= 4.5 mv*7.74 lbs/mv*6.5 inches + 78 lbs(2.1–1.85 inches)
≈ 246 in–lbs.

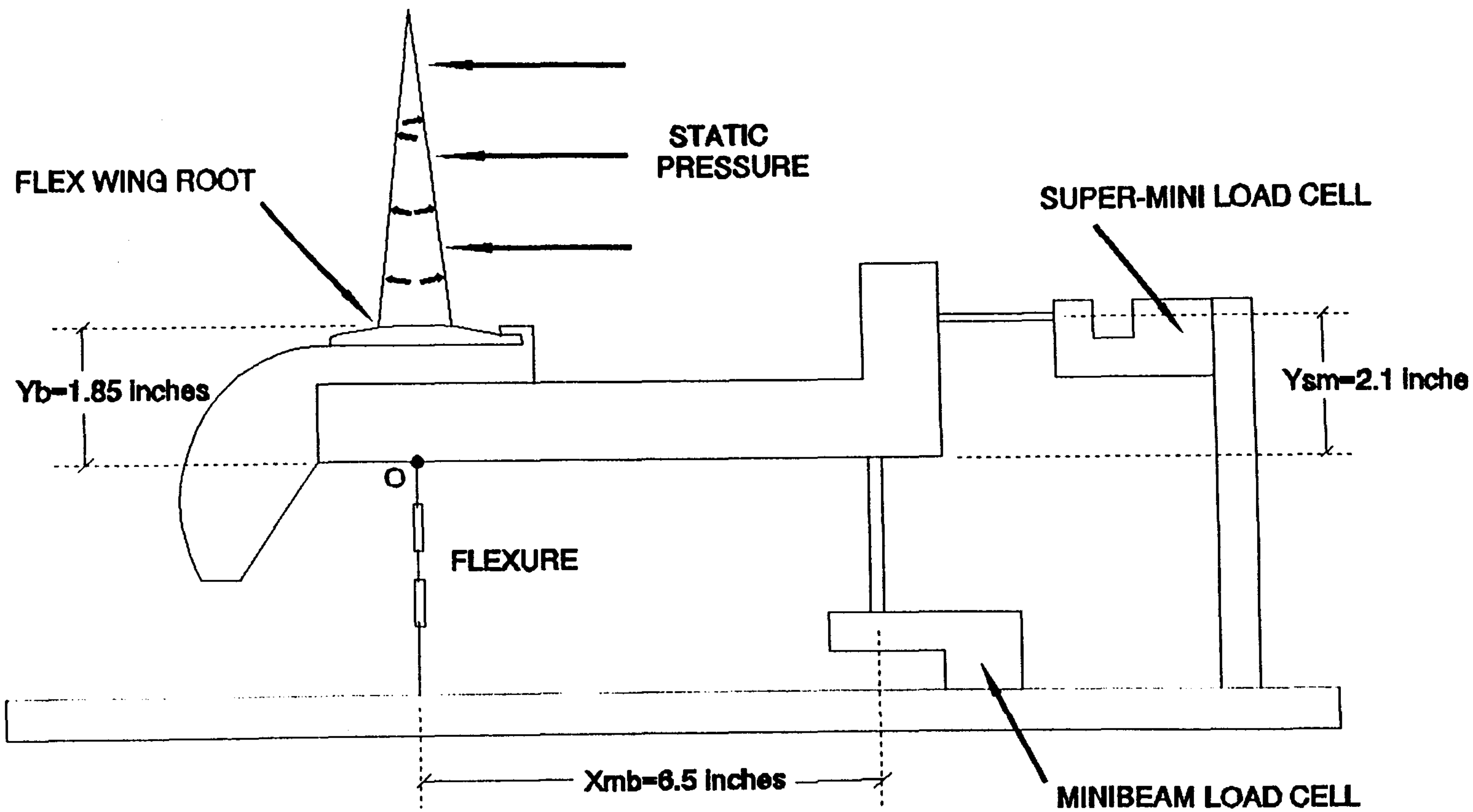

Figure 8. Flex Wing Normal Force and Root Bending Moment Calculations

IV. RESULTS

Static pressure testing was performed on a total of four flex wings, labeled Number 2, Number 1, Number 4, and Number 5. Flex wings Number 2 and Number 1 have .016 inch skin thickness and flex wings Number 4 and Number 5 have .012 inch skin thickness. All of the flex wings have .010 inch stiffener thickness.

A series of three tests were performed on flex wing Number 2 and a series of four tests were performed on flex wings Number 1, Number 4, and Number 5. The pressure test results are presented on plots in Appendix A and the maximum normal force and root bending moments are summarized in Table 2. The first three tests were performed by maintaining a pressure differential of internal pressure equals one–half of external pressure. A pressure differential of internal pressure equals external pressure was maintained during the fourth test. All of the tests were performed until wing buckling failure occurred. It is noted that no physical damage was visibly observed on any of the wings after tests were completed; buckling failure would occur, the pressure loading was removed and the flex wings would spring into their original shape. Flex wings Number 1 and Number 4 were deformed in the collapse and stowage positions prior to static pressure testing.

Table 2. Flex Wing Static Pressure Testing Results

	FLEX WING #2 (.016 inches)		FLEX WING #1 (.016 inches)		FLEX WING #4 (.012 inches)		FLEX WING #5 (.012 inches)	
	NORMAL FORCE (LBS)	ROOT BENDING MOMENT (IN-LBS)	NORMAL FORCE (LBS)	ROOT BENDING MOMENT (IN-LBS)	NORMAL FORCE (LBS)	ROOT BENDING MOMENT (IN-LBS)	NORMAL FORCE (LBS)	ROOT BENDING MOMENT (IN-LBS)
TEST 1 $P_{INT} = 1/2\ P_{EXT}$	93	246	93	233	53	124	79	205
TEST 2 $P_{INT} = 1/2\ P_{EXT}$	53	162	60	151	28	69	39	109
TEST 3 $P_{INT} = 1/2\ P_{EXT}$	--*	---*	49	123	28	69	46	110
TEST 4 $P_{INT} = P_{EXT}$	49	111	51	136	23	80	44	110

* This test was not performed.

Table 2 results indicate that the maximum average normal force and root bending moment (Test 1) for the .016 inch wings are 93 lbs and 240 in–lbs, respectively. Previous studies [1] indicate an average normal force and root bending moment of 81 lbs and 253 in–lbs, respectively, for .016 inch wings. Results also indicate that the normal forces and root bending moments for the .012 inch wings are 53 and 79 lbs, and 124 and 205 in–lbs, respectively. Previous studies indicate that the normal force and root bending moment ranged from 63 to 79 lbs and 168 to 210 in–lbs, respectively, for the .012 inch wings.

Test Numbers 2 and 3 results indicate that the maximum root bending moments are reduced by 50 to 90 percent after the initial test. Test Number 4 (internal pressure equals external pressure) results are similar to tests 2 and 3.

V. CONCLUSIONS AND RECOMMENDATIONS

Six flex wings were successfully fabricated and delivered to the Structural Analysis and Design Function for experimental testing. A manufacturing summary report of the flex wing fabrication is presented in Appendix C. The workmanship on the fabrication of the wings compared well with previous wings.

Static pressure testing was performed on four of the flex wings to simulate an aerodynamic pressure loading. Static pressure was applied until bucking failure occurred at which time the wings would deform significantly and no longer withstand the loading. The pressure test results are summarized in Table 2 of this report.

Test results indicated a maximum root bending moment of 205 and 246 in–lbs for the .012 and .016 inch skin thickness, flex wings, respectively. These results compared well with previous studies [3] that indicated an average root bending moment of 186 and 253 in–lbs for the .012 and .016 inch wings, respectively. However, there was a wide variance between test results on the .012 inch wings.

Many of the fabrication procedures outlined in the manufacturing summary report were performed by hand and may contribute the most to the variance in the test results. Test data also suggests that the flex wings may be weakened by the collapse and stowage deformations prior to pressure loading; since the root bending moments were less on the wings with these deformations verses the wings with no prior deformations. However, the test results for the .016 inch wings compared well with each other, which suggests that this conclusion can not be drawn based on this experimental data. Previous studies [3] indicated yielding with the combined residual and collapse stresses.

The findings of these tests confirm that the baseline flex wing [1] will not meet the performance requirements for TACAWS. The root bending moment required for a 10 g TACAWS missile with flex wings is 376 in–lbs.

Table 2 results indicated that the flex wings were significantly weakened after the first pressure test was performed. The maximum root bending moments were reduced 50 to 90 percent on the second test. These findings also appear in previous studies which indicate that significant plastic deformation occurs during the first test.

It is recommended that the results of the static pressure tests be used to verify the finite element model [1] and build the flex wing data base. It is also recommended that the effects of collapse and stowage deformations on the flex wing flight load performance be further studied.

REFERENCES

1. Lucas, L. D., "Flex Wing Finite Element Analysis and Design for The Army Combined Arms Weapon System (TACAWS)," Technical Report RD–ST–94–2, U. S. Army Missile Command, Huntsville, AL, December 1993.

2. "Flex–Wing Manufacturing Summary," Campbell Engineering, Inc., Huntsville, AL, December 1994.

3. Cornelius, C. S., Lovelace, D. E., Schexnayder, M. C., Pirtle, D. A., Sanders, G. A., and Lawson, L. J., "Alternate Antitank Airframe (AATAC) Configuration Flex–Wing Structural Development," Technical Report RD–ST–88–3, U. S. Army Missile Command, Huntsville, AL, April 1989.

APPENDIX A
FLEX WING STATIC PRESSURE TEST RESULTS

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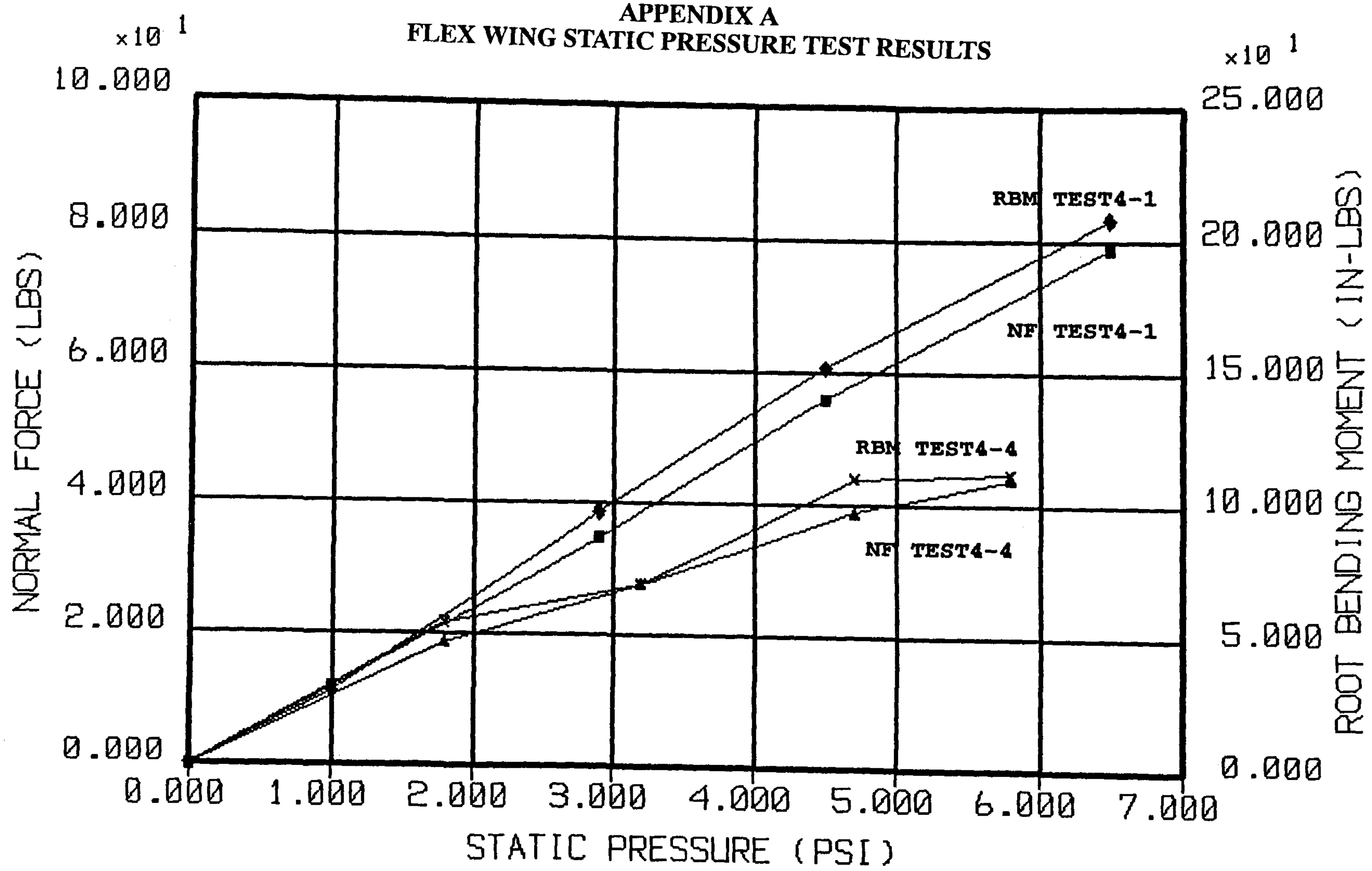
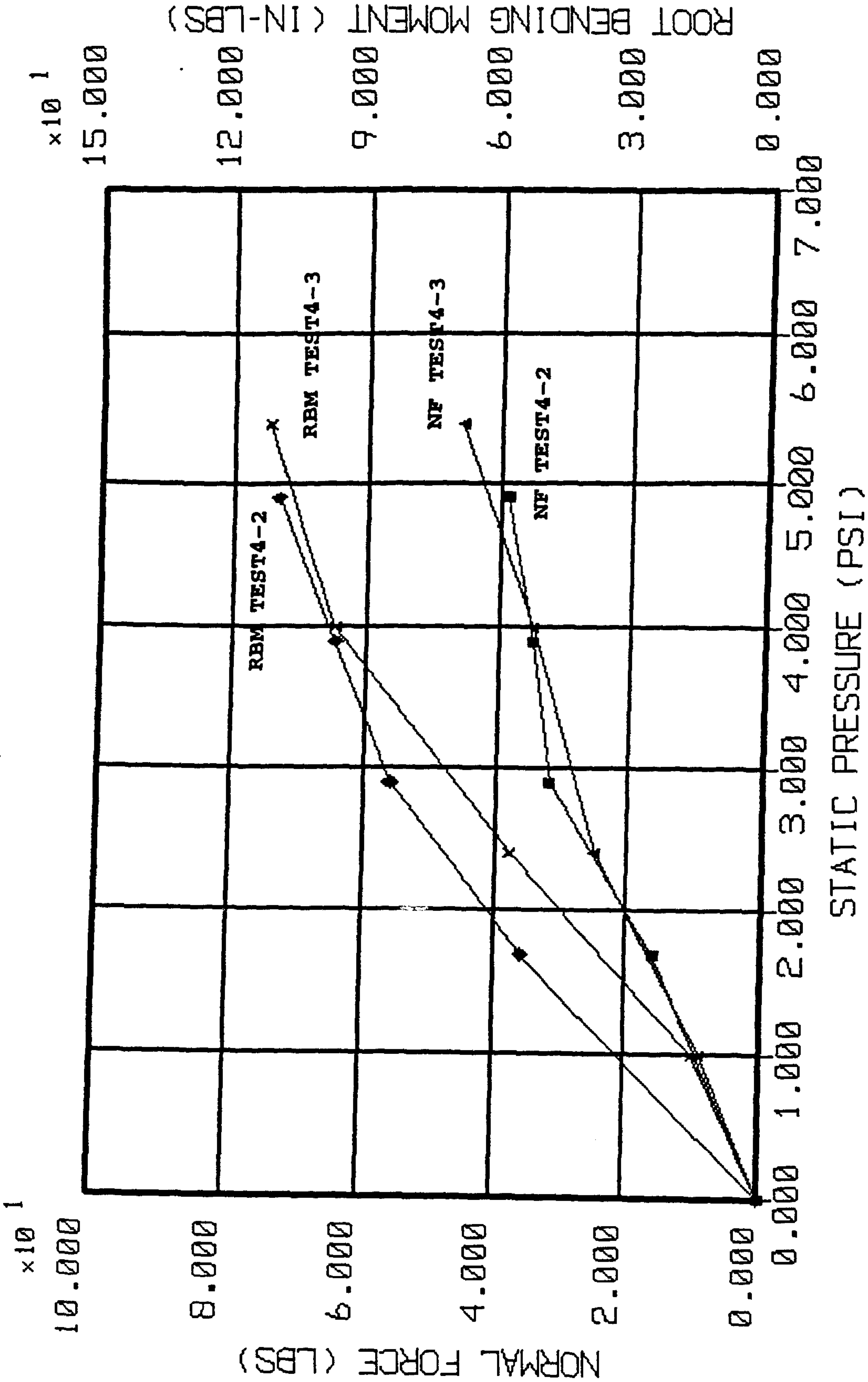
FLEX WING STATIC PRESSURE TEST RESULTS





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NF TEST4-3
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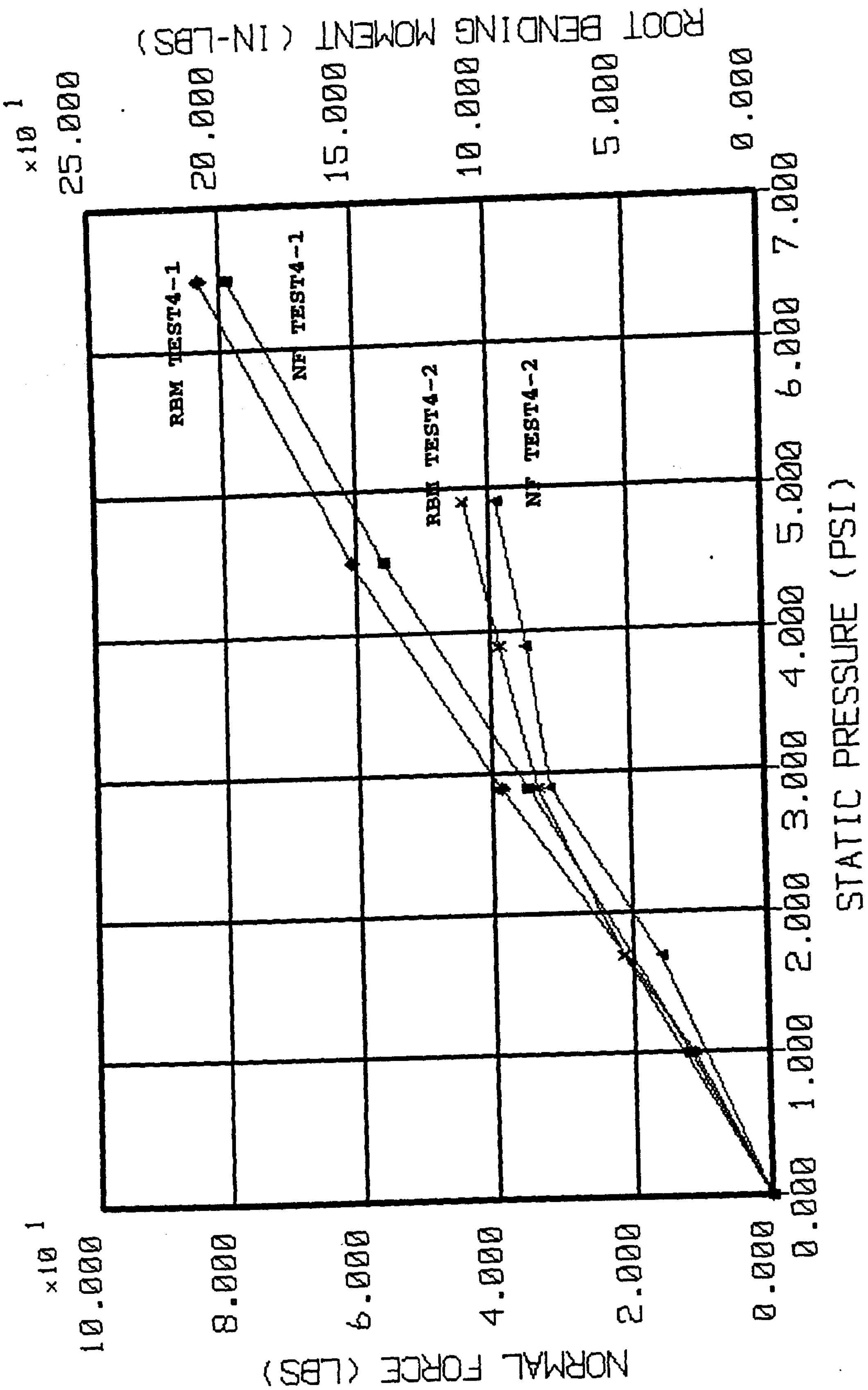
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STATIC PRESSURE (PSI)
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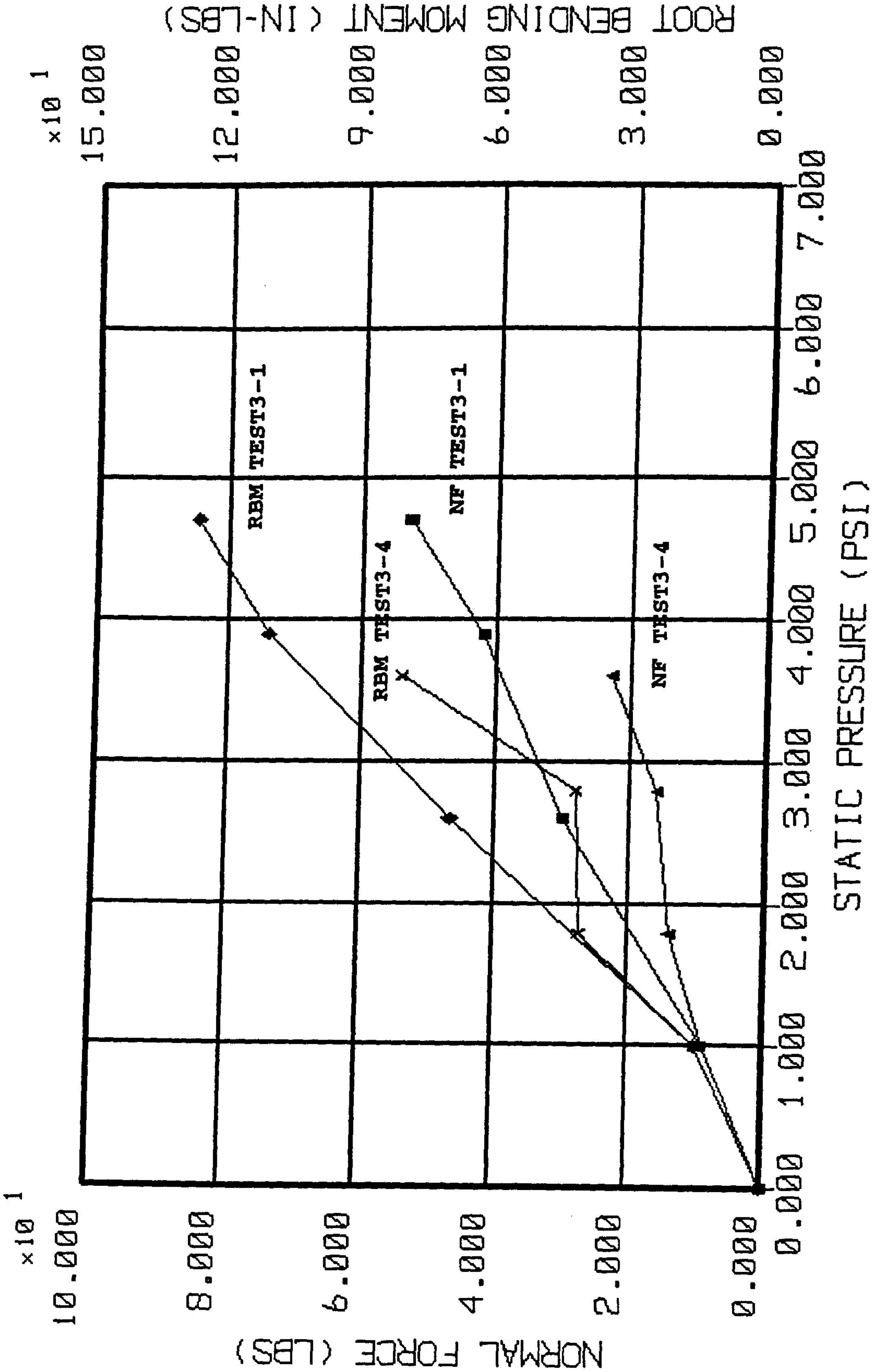
NF TEST4-2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NF TEST3-4
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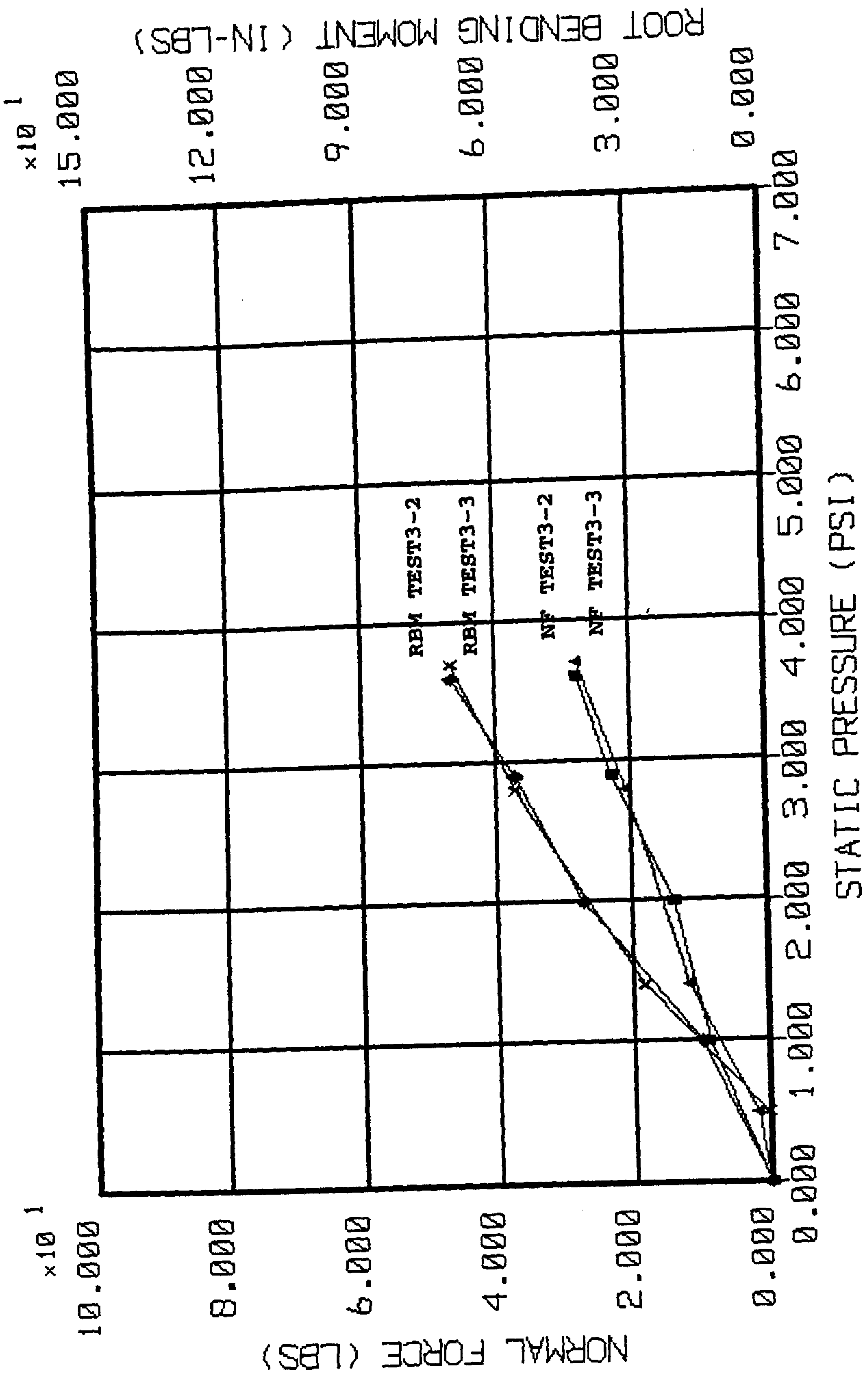
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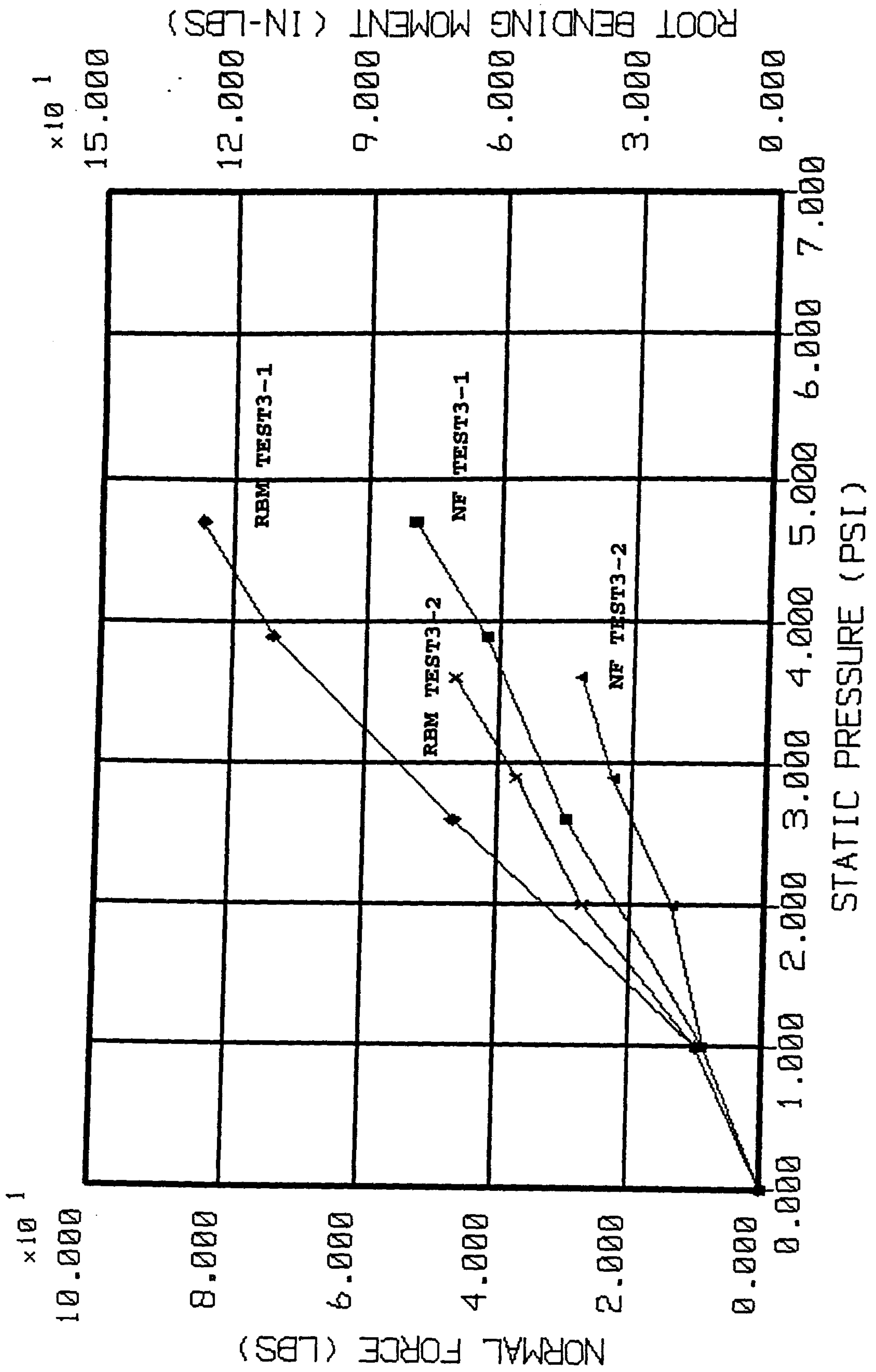
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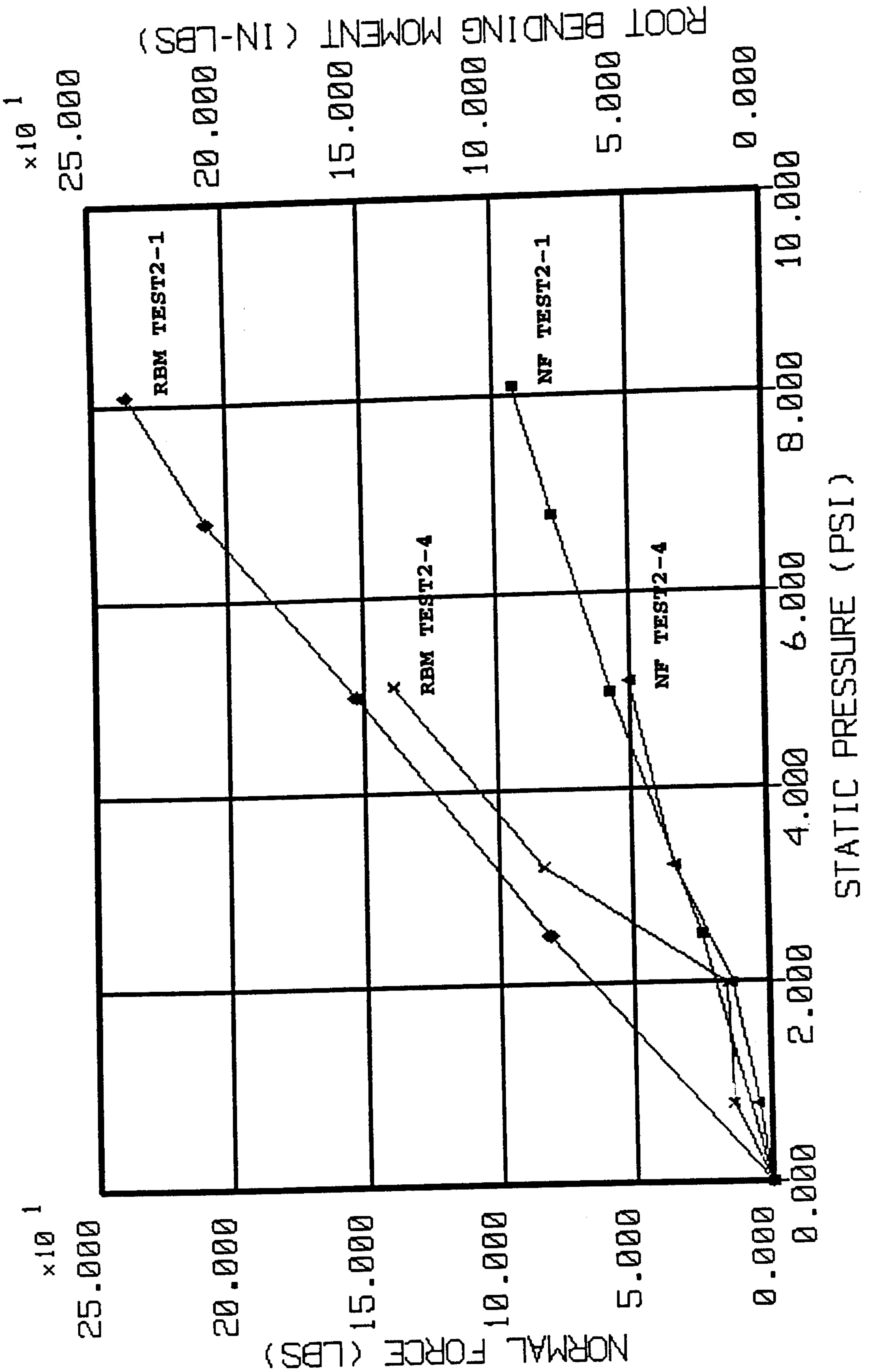
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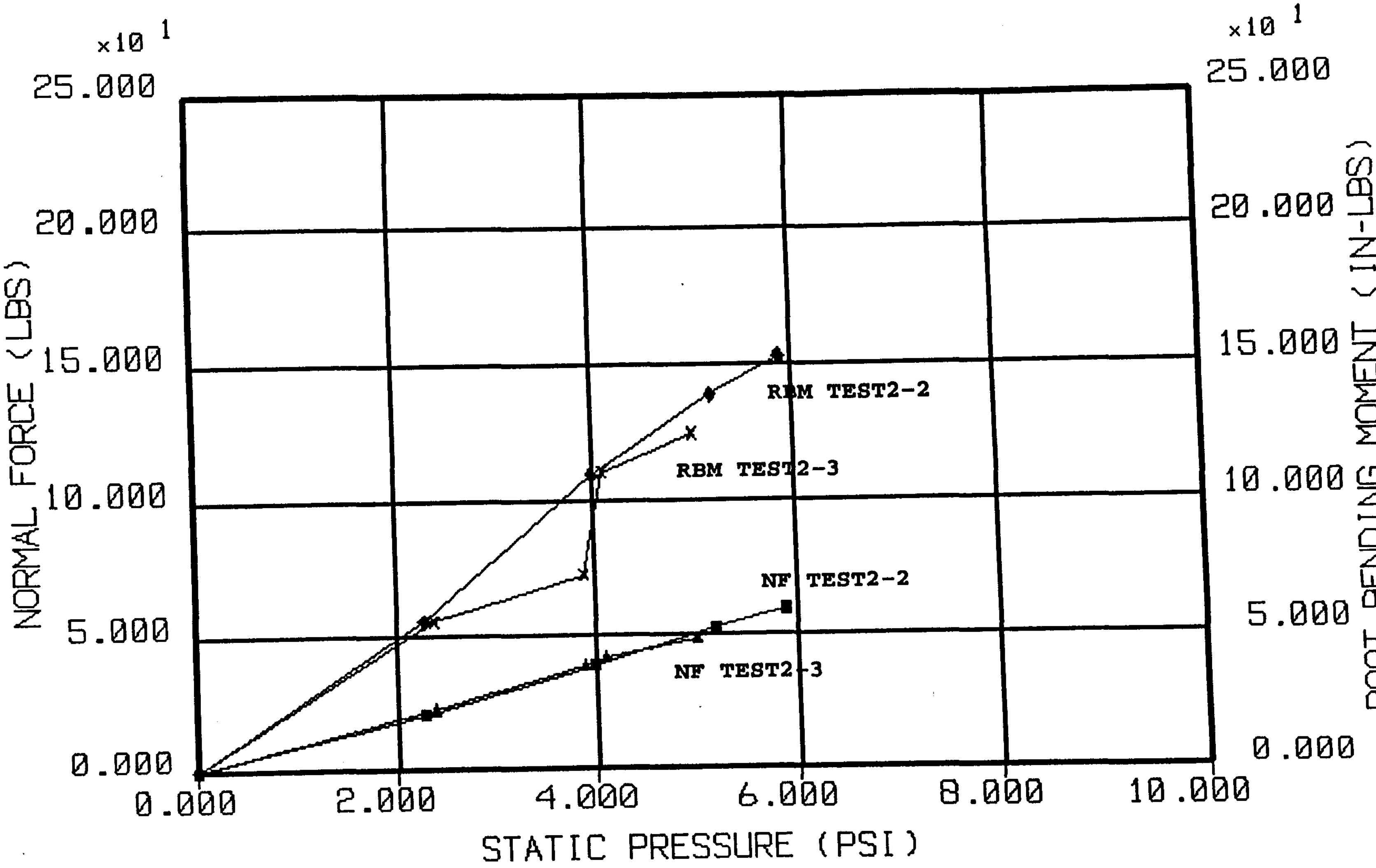

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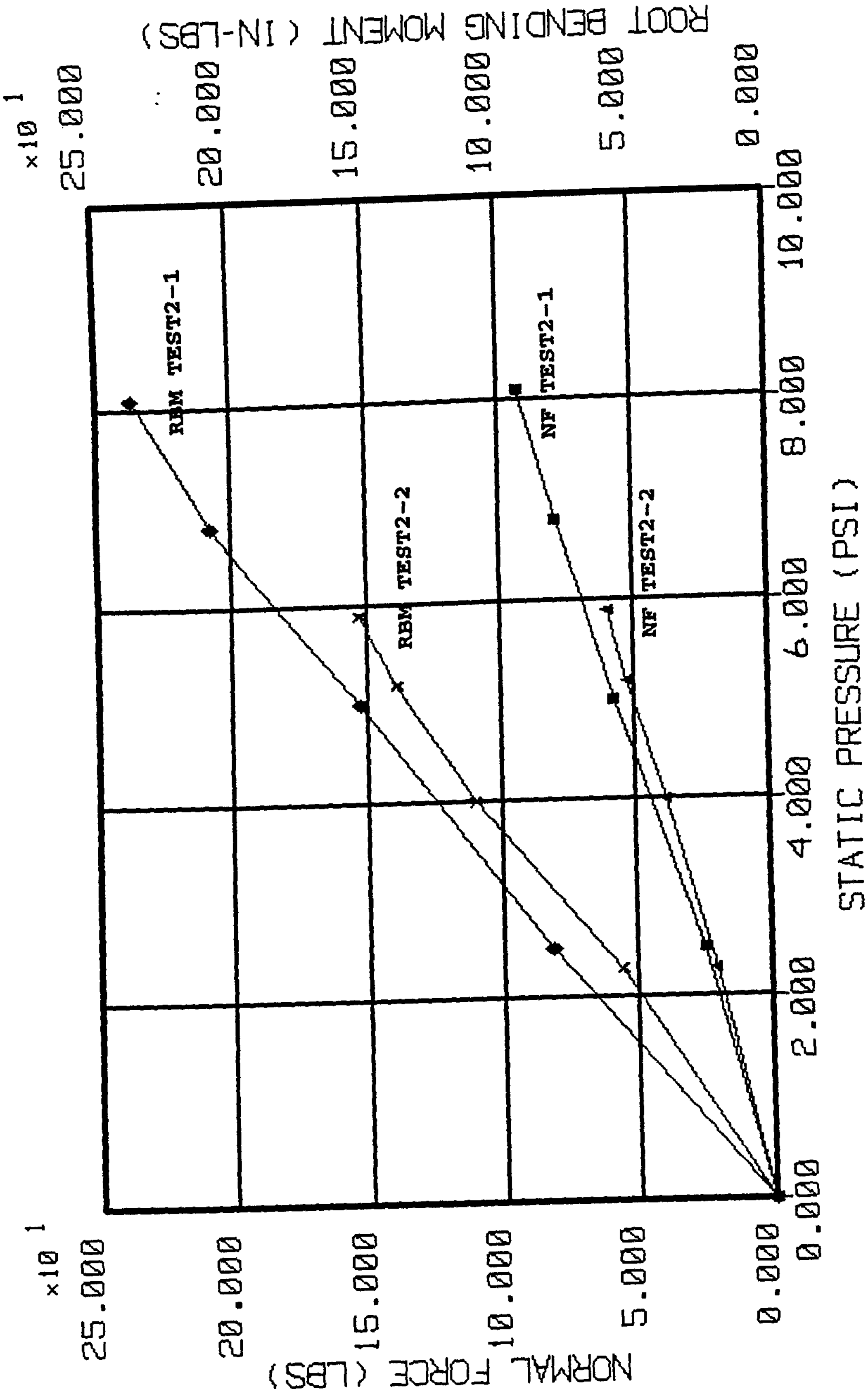
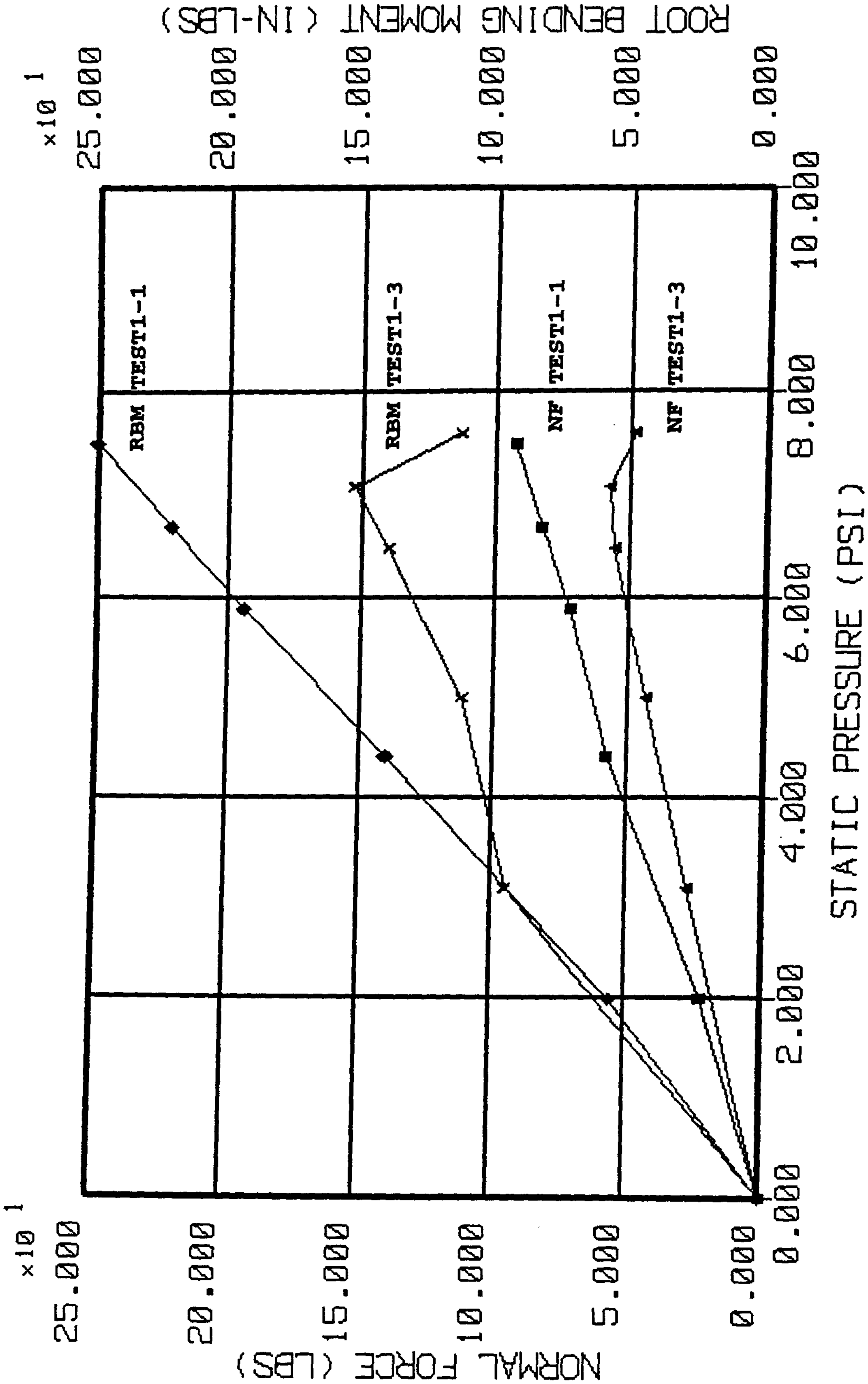
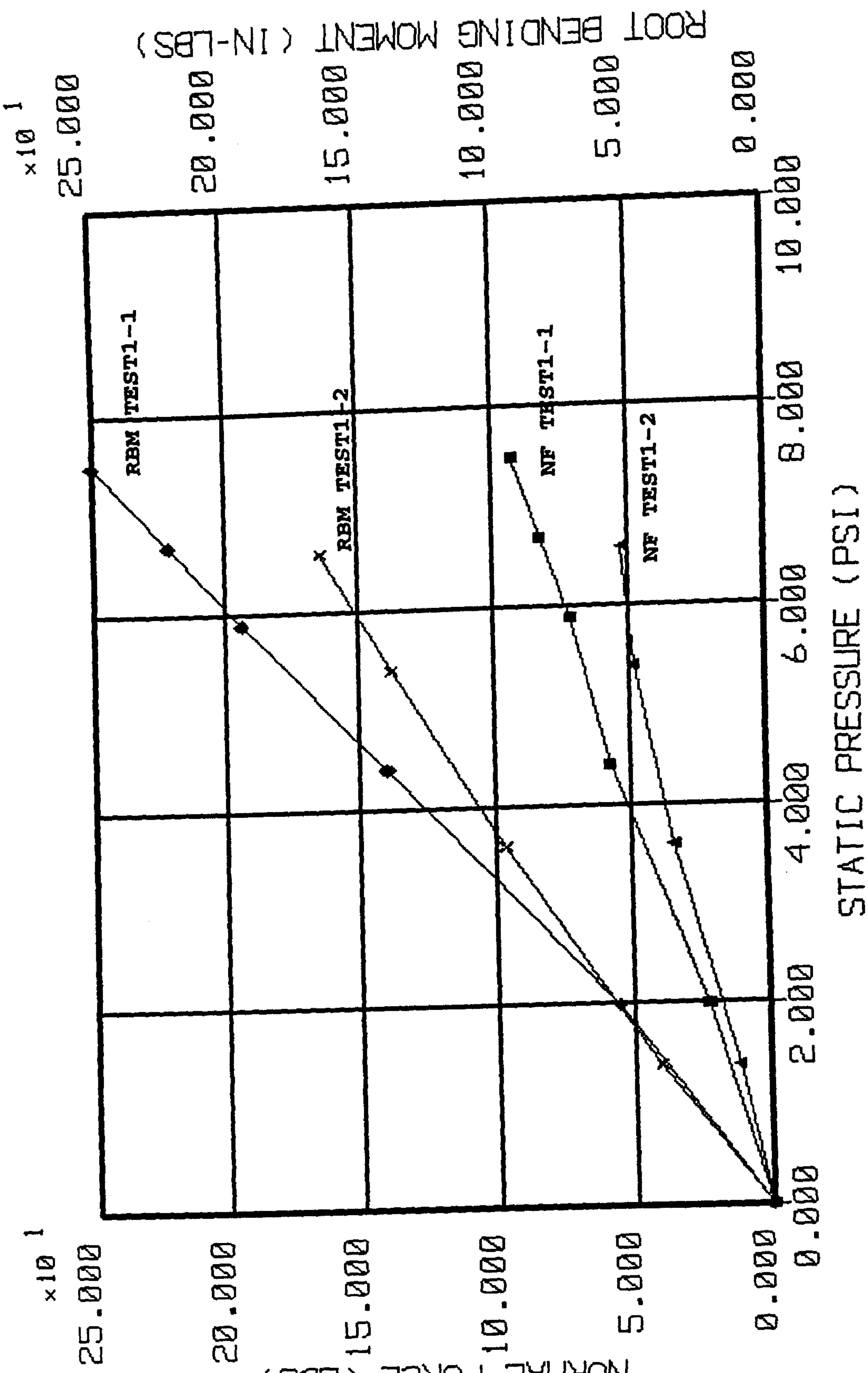
NF TEST2-2
NF TEST2-3



ROOT BENDING MOMENT (IN-LBS)
×10 1
25.000
20.000
15.000
10.000
5.000
0.000
RBM TEST2-1
RBM TEST2-2
NF TEST2-1
NF TEST2-2
0.000
2.000
4.000
6.000
8.000
10.000
STATIC PRESSURE (PSI)
×10 1
25.000
20.000
15.000
10.000
5.000
0.000
NORMAL FORCE (LBS)



ROOT BENDING MOMENT (IN-LBS)
×10 1
25.000
20.000
15.000
10.000
5.000
0.000
RBM TEST1-1
RBM TEST1-3
NF TEST1-1
NF TEST1-3
0.000
2.000
4.000
6.000
8.000
10.000
STATIC PRESSURE (PSI)
NORMAL FORCE (LBS)


ROOT BENDING MOMENT (IN-LBS)
x10 1
25.000
20.000
15.000
10.000
5.000
0.000
RBM TEST1-1
RBM TEST1-2
NF TEST1-1
NF TEST1-2
0.000
2.000
4.000
6.000
8.000
10.000
STATIC PRESSURE (PSI)
x10 1
25.000
20.000
15.000
10.000
5.000
0.000
NORMAL FORCE (LBS)

APPENDIX B
LOAD CELL SPECIFICATIONS AND CALIBRATION

APPENDIX B
LOAD CELL SPECIFICATIONS AND CALIBRATION

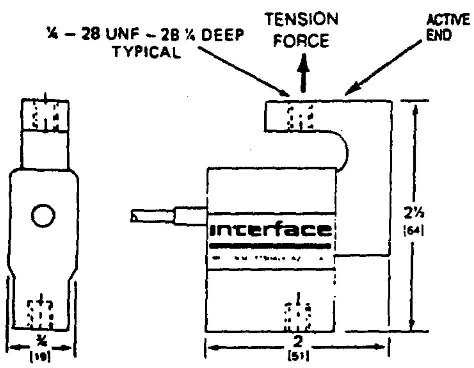
interface

ADVANCED FORCE MEASUREMENT

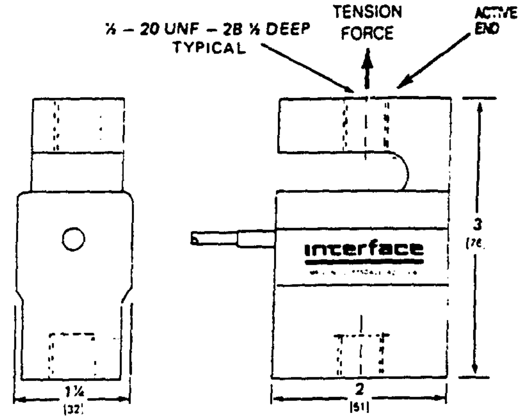
CALIBRATION CERTIFICATE
INSTALLATION INFORMATION

INSTALLATION DIMENSIONS

INCHES [mm]



SM-10, SM-25, SM-50, SM-100, SM-250

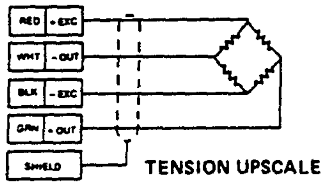


SM-500, SM-1000

ELECTRICAL INFORMATION

SM Series is provided with a 4-conductor shielded cable (AWG 28) 5 feet (1.5m) long.

Wiring Color Code complies with ISA S37.8 "Specifications and Tests for Strain Gage Force Transducers" and SMA Load Cell Terminology.



APPLICATION NOTES

1. The Super-Mini load cell is for controlled environment applications. In general, it can be used anywhere a readout instrument can be used.
2. At least one diameter thread engagement is desirable, approximately ¼" (6mm) on the SM-10 (45N) through 250 pound (1000N) ranges and ½" (12mm) on the SM-500 (2000N) and 1000 (5000N) units.
3. Jam nuts may be used, however care should be exercised to not apply excessive torque across the load cell. Torque should be reacted against the load cell structure immediately adjacent to the jam nut.

SM-10:	5 - inch pounds	(0.55N•m)
SM-25:	10 - inch pounds	(1.1N•m)
SM-50:	20 - inch pounds	(2.2N•m)
SM-100, 250:	40 - inch pounds	(4.5N•m)
SM-500, 1000:	200 - inch pounds	(22.5N•m)

4. The force to be measured should be applied to the active end of the cell to eliminate possible errors due to cable interaction. The active end of the cell is separated from the cable/connector side by the slot (cutout) in the flexure (the serial number is always shown on the inactive side).
5. **NOTE: Please exercise caution during handling and installation of these load cells. The application of a force equaling more than 150% of rated capacity (15 lbs. on SM-10; 37.5 lbs. on SM-25, etc.) can result in irreparable damage.**
6. These units are not intended for submerged operation. A Moisture Resistant coating is applied to protect SM Series for capacities 25 thru 1000 lbs. from high humidity conditions up to and including 95% Relative Humidity and periodic exposure to condensation.

Bottoming out of the mounting stud can cause irreparable damage to the load cell.

PERFORMANCE DATA

Input Resistance — Ohms	350 + 40/-3.5
Output Resistance — Ohms	350 ± 3.5
Recommended Excitation — VDC	10
Non-Linearity — % Rated Output	<±0.03
Hysteresis — % Rated Output	<±0.02
Temp. Range Compensated — °F (-15 to 65°C)	0 to 150
Temperature effect on zero — % Rated Output/100°F (55.6°C)	±0.15
Zero Balance — % Rated Output	<±1

WARRANTY & CERTIFICATION STATEMENT ON OTHER SIDE

SUPER-MINI LOAD CELL

Model: SM-250 Date: 01-20-94

Capacity: 250 LBS Serial: C48510

Output, Tension mV/V: 3.211

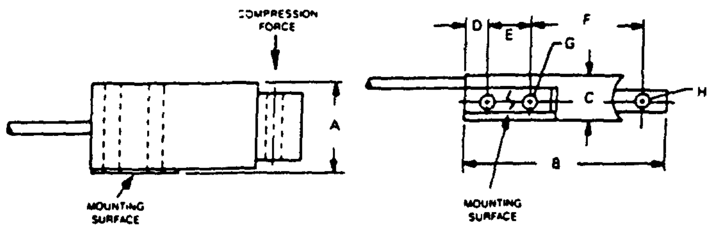
INTERFACE, INC.
7401 E. Butherus Dr.
Scottsdale, Arizona 85260 U.S.A.
Telephone: (602) 948-5555 • Fax: (602) 948-1924
Telex: 825-882

interface

ADVANCED FORCE MEASUREMENT

CALIBRATION CERTIFICATE
INSTALLATION INFORMATION

INSTALLATION DIMENSIONS



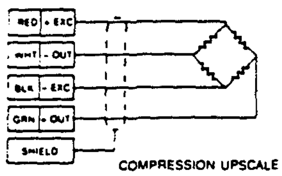
Model		A	B	C	D	E	F	G	H
MB-5, 10, 25, 50	inch	1	2 3/8	1/2	1/4	.500	1 5/16	11/64	11/64
75, 100, 150	mm	25.4	60.3	12.7	6.4	12.7	33.3	4.4	4.4
MB-250	inch	1	2 3/8	3/4	1/4	.500	1 5/16	11/64	11/64
	mm	25.4	60.3	19.1	6.4	12.7	33.3	4.4	4.4

Mounting instructions: Fasten securely to flat rigid surface with two 8-32 X 1¼ screws. Torque to 24-inch pounds (2.7N·m) for best performance.

ELECTRICAL INFORMATION

MB Series is provided with a 4-conductor shielded cable (AWG 28) 5 feet (1.5m) long.

Wiring Color Code complies with ISA S37.8 "Specifications and Tests for Strain Gage Force Transducers" and SMA Load Cell Terminology.

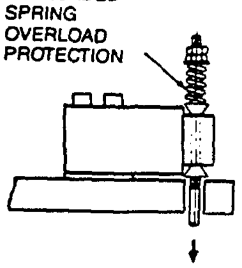


COMPRESSION UPSCALE

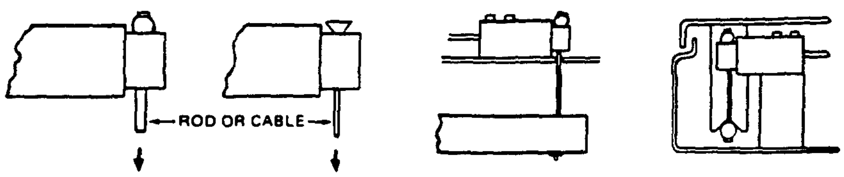
APPLICATION NOTES

1. The Minibeam load cells are designed for controlled environment applications. In general, they can be used anywhere a readout instrument is used.
2. NOTE: Please exercise caution during handling and installation of these load cells. The application of a force equaling more than 150% of the rated capacity (7.5 lbs. on MB-5; 15 lbs. on MB-10; 37.5 lbs. on MB-25, etc.) can result in irreparable damage.
3. These units are not intended for submerged operation. A Moisture Resistant coating is applied for capacities 25 thru 250 lbs. to protect MB Series from high humidity conditions up to and including 95% Relative Humidity and periodic exposure to condensation.

PRELOADED SPRING OVERLOAD PROTECTION



For spring overload details request IFI #32



TYPICAL INSTALLATION — ATTACHMENT METHODS

PERFORMANCE DATA

Nominal Output—mV/V 3
Input Resistance—Ohms .... 350 + 40/ −3.5
Output Resistance—Ohms .... 350 ± 3.5
Recommended Excitation .... 10 VDC
Non-Linearity—% Rated Output .... < ±0.03%
Hysteresis—% Rated Output .... < ±0.02%
Compensated Temp. Range .... 0°F to 150°F (-15°C to 65°C)
Temperature effect on zero—% Rated Output/100°F (% Rated Output/55.6°C) .... ±0.15
Zero Balance—% Rated Output .... < ±1

WARRANTY & CERTIFICATION STATEMENT ON OTHER SIDE

MINIBEAM LOAD CELL

Model: MB-250 Date: 03-10-94
Capacity: 250 LBS Serial: C28181
Output, Tension mV/V : -3.230
Output, Compression mV/V: 3.230

INTERFACE, INC.
7401 E. Butherus Dr.
Scottsdale, Arizona 85260 U.S.A.
Telephone: (602) 948-5555 • Fax: (602) 948-1924
Telex: 825-882

APPENDIX C
FLEX WING MANUFACTURING SUMMARY

APPENDIX C
FLEX WING MANUFACTURING SUMMARY

TACAWS Flex–Wing Hardware Fabrication and Support

Flex–Wing Manufacturing Summary

Prime Contract No. DAAH01–94–D–R002
Mesa Subcontract No. Mesa–94–R002–001

December 23, 1994

Campbell Engineering, Inc.
3415 Stanwood Boulevard
Huntsville, Alabama 35811
(205) 852–8720

1.0 Introduction

This report summarizes the fabrication and assembly of the TACAWS Flex-wings. The Flex-wings were fabricated by Campbell Engineering, Inc. (CEI) for Mesa Associates, Inc. (Mesa) per drawings provided by Mesa. The drawings were annotated near completion of the task per direction of the Structures Directorate. The annotated Drawings are included in Appendix A.

2.0 Fabrication and Assembly

2.1 Wing Half Forming

The Flexwing Fabrication process began by producing Formed Wing Halves per Drawing Nos. TCW00045 and TCW00046 and Doublers per Drawing No. TCW00044. All of these components were fabricated from 17-7 Stainless Steel per MIL-S-25043 in the annealed condition. Initially, the Doublers were made of .032" thick material and the Wing Halves were made of .016" material. The final configuration was modified per instructions from the Structures Directorate so that all of the Doublers were .010" thick and some Wing Halves were made of .016" thick Stainless Steel and some were made of .012" thick material. These changes are reflected in the annotated drawings.

The fabrication process for the Formed Wing Halves and the Doublers began by shearing the material to size. The material was then stacked and the flat patterns were machined on a CNC milling machine per Drawing Nos. TCW00042, TCW00043, and TCW00044. The rectangular cutouts were rough machined on the CNC milling machine and finish machined using Electrical Discharge Machining (EDM) to obtain the required sharp corners.

Once the flat patterns were machined, they were hand formed by a CEI subcontractor per Drawing Nos. TCW00044, TCW00045, and TCW00046 using manual sheet metal working equipment. Fabrication by this process did not provide parts completely per print as the drawing tolerance of +/-.010" cannot be obtained using this method of manufacture. Stamping the parts using formed dies could possibly produce parts within tolerance, but would have been far too expensive for the scope of this delivery order. The formed components were checked against templates and showed a maximum deviation of the contour of approximately .030". The actual deviation was probably .015" or less in most places. Non-conformance reports (NCR's) for the components are included in Appendix B. The parts had to be handled with extreme care since their shape could be easily changed in the annealed condition. The components were rechecked after each handling operation such as deburring, cleaning, etc.

2.2 Wing Half/Doubler Assembly

The Doublers were next welded to the Wing Halves per Drawing No. TCW00047. This was performed while the material was still in the annealed condition. A number of attempts were made to spot weld the components by CEI's local subcontractor using two different types of resistance spot welding machines. These attempts were unsuccessful since the equipment used was older and lacked the necessary controls and repeatability for firing force, pulse length, and power. It also appeared that the .080" diameter weld nugget size required by the drawings was impractical as it would not be possible to fit all of the welds shown on the drawing within the space available and also due to deformation caused by the amount of heat input.

Noting that specific settings were given for a Unitek 250 power supply and Model HFT handpiece in the report entitled "Alternate Antitank Airframe (AATAC) Configuration - Flexwing Structural Development", MICOM, 1989, CEI sought a subcontractor who owned this equipment. After failing to find a company who owned the proper equipment and would perform the work, CEI arranged for the Applications Lab of Unitek-Miyachi, Inc. of Monrovia, California to perform the spot welding and schedule development. Unitek - Miyachi is the manufacturer of the resistance spot welding equipment used in the report referenced above.

Unitek - Miyachi welded the Doublers to the Wing Halves per Drawing No. TCW00047 with the exception that a weld nugget diameter of .062" was used instead of .080" for improved appearance, reduced weld expulsion, and reduced distortion. The Doublers were closely aligned to the Wing Halves using gage pins in the center hole and rectangular cutouts before welding. The Wing Half/Doubler Assemblies were checked once again to the templates, verifying that the proper contour had been maintained. Shear testing of the spot welds produced an average pull strength of 128 pounds for the .010" Doubler welded to the .012" Wing Half and an average pull strength of 144 pounds for the .010" Doubler welded to the .016" Wing Half. Weld schedules and test data are included in Appendix C.

2.3 Heat Treatment

After welding the Wing Halves and Doublers, they were heat treated to Condition TH1050 per MIL-H-6875 by a CEI subcontractor. Prior to heat treating, the parts were cleaned and deburred. To support the parts during heat treatment so that they would not sag or distort, they were packed in a bed of .062" diameter carbon steel balls in a steel box. The wings were gently seated in the balls and stacked on top of one another. The Wing Halves with folded tabs were stacked separately from the other Wing Halves since they are shaped slightly differently. The box was then completely filled with the steel balls and closed. Hardness tests after the heat treatment indicated a hardness of Rockwell C42, corresponding to an ultimate tensile strength of 194 ksi. MIL-H-6875 requires a minimum strength of 180 ksi (Rockwell C39-40), so the heat treat process met

2.3 Heat Treatment (continued)

specification. The parts were mechanically cleaned to remove the heat scale and were checked once again to the templates to verify that the proper contour had been maintained. The .016" thick Wing Halves held their shape and the .012" thick Wing Halves flattened only slightly at the central contour of the narrow end of the Wing Half. This is the same area that requires flattening in order to tuck under the folded tab of the mating Wing Half.

2.4 Flex-Wing Assembly

The final assembly of the Flex-Wings consisted of spot welding the Wing Halves together and trimming away the excess material. Proper clamping of the Wing Halves together is essential for the proper assembly of the Flex-Wings. CEI designed and fabricated a welding fixture consisting of the components in Drawing Nos. 94C2406, 94C2407, 94C2408, and 94C2409 (Appendix D). This fixture permits the proper clamping of the Wing Halves together and accurately positions the phenolic spot weld templates and holds them in place during the welding procedure. The Wing Halves were assembled as follows for welding after degreasing:

- A Wing Half - Bottom (with folded tab) and a Wing Half - Top (without folded tab) were assembled together by tucking the end of the Wing Half - Top under the tab of the Wing Half - Bottom. These two components were then placed on the three .125" diameter dowel pins in the Fixture Top Plate, P/N 94C2409, with the folded tab on the Wing Half - Bottom facing the corresponding groove in the Fixture. The Fixture Bottom Plate, P/N 94C2408, was then slipped over the same three dowel pins with the machined surface facing the Wing Halves. The two halves of the Fixture were then pulled tightly against one another using two 1/4-20 x 1.75" long Socket Head Cap Screws (Figure 2.4.1). It is important that none of the Clamp Bars, P/N 94C2407, are attached to the Fixture Top Plate or Bottom Plate at this point.

- Clamp Bars 94C2407-2 and 94C2407-6 were placed on a flat surface. Four .125" diameter x 2" long dowel pins were inserted in the outermost matching holes and one Phenolic Template, 94C2406, was placed on the dowel pins on each side with the closely spaced hole patterns toward the inside. (Figure 2.4.2)

- The clamped Wing Halves were then placed on the Clamp Bars and Phenolic Templates positioned as described above so that the four short dowel pins in the Fixture align with the corresponding holes in the Clamp Bars. The two remaining Phenolic Templates were placed over the 2" long dowel pins so that their holes were aligned with the Templates positioned earlier. Clamp Bars 94C2407-1 and 94C2407-2 were placed over the four short dowel pins in the fixture clamping the Wing Halves together as well as the 2" long dowel pins positioning the Phenolic Templates (Figure 2.4.3). The upper and lower Clamp Bars were attached to one another using

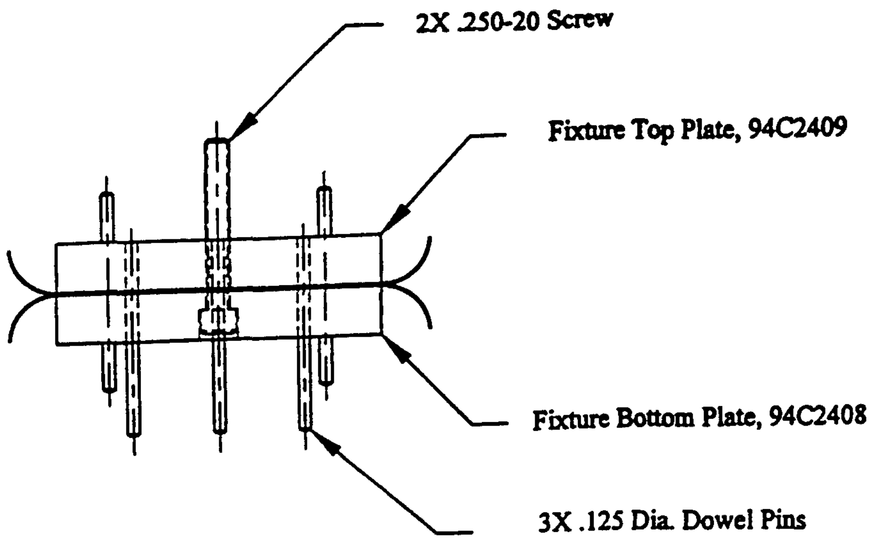


Figure 2.4.1
Root End View

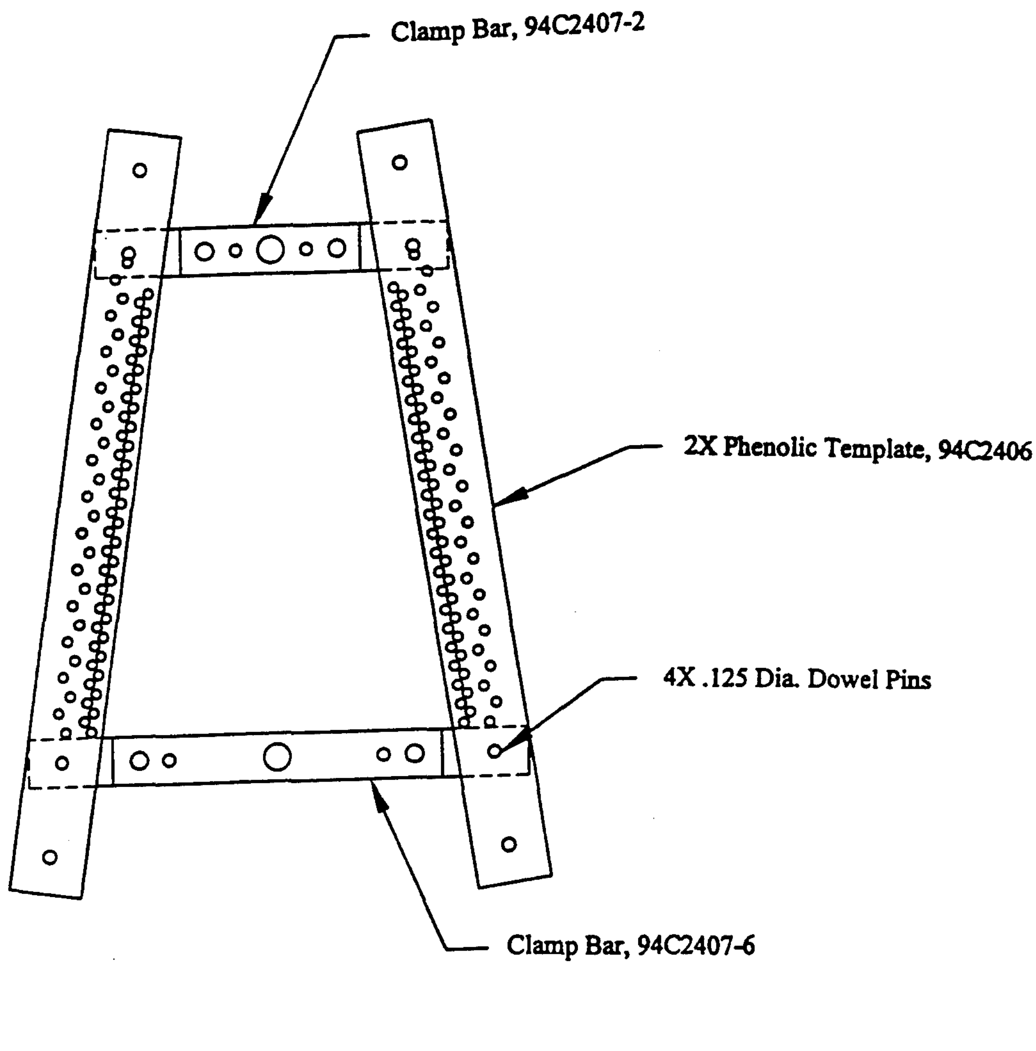


Figure 2.4.2
Top View

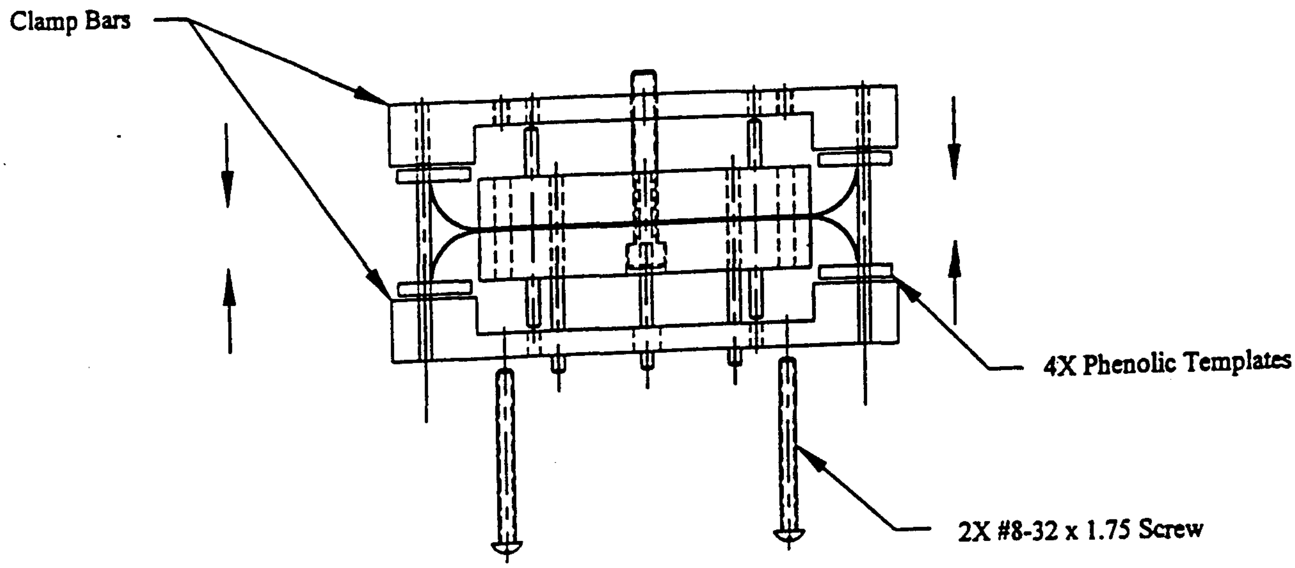


Figure 2.4.3
Root End View

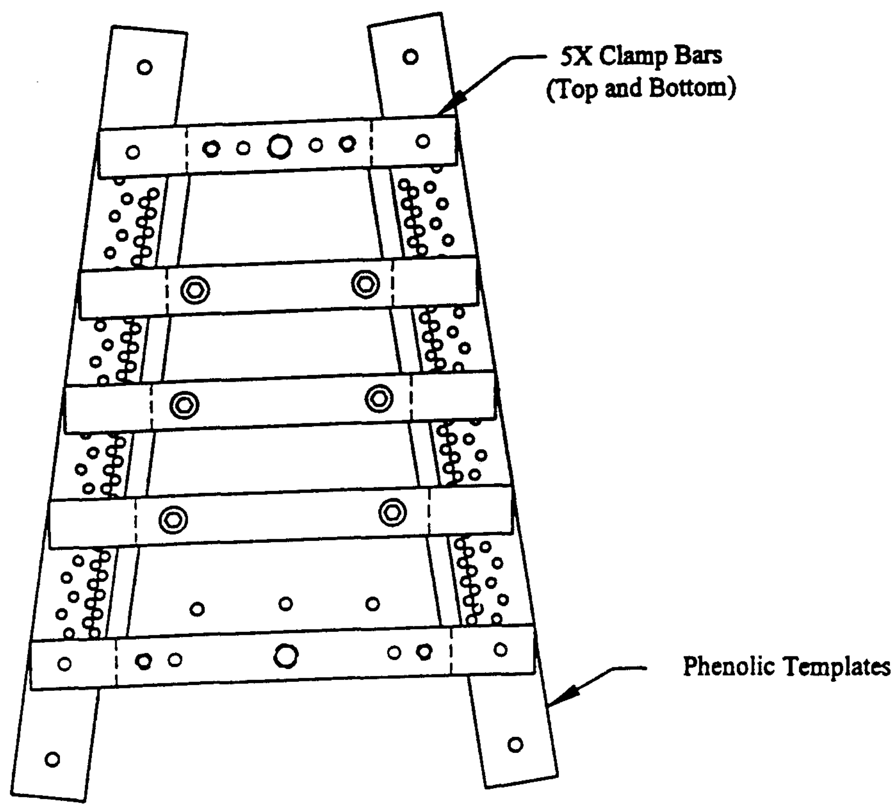


Figure 2.4.4
Top View

2.4 Flex-Wing Assembly (continued)

four #8-32 x 2" long screws. They were not fully tightened at this point. The remaining Clamp Bars (94C2407-3, -4, and -5) were attached with #8-32 x .75" long socket head cap screws to the Fixture used to clamp the Wing Halves together. Tightening of the screws on all the Clamp Bars was alternated so that the Phenolic Templates were kept somewhat flat and straight. When the Clamp Bars were all fully tightened, a visual inspection was made to ensure that the Wing Halves were clamped tightly together (Figure 2.4.4). Where gaps were present between the upper and lower Wing Halves, shims were placed between the Clamp Bars and the Phenolic Templates to eliminate the gaps.

- At this point, the Wings were ready for welding. Spot welds were placed in all of the holes that were accessible in the Phenolic Templates, beginning with the outermost rows. The two outer rows of spot welds are to aid in holding the Wing Halves together when the Clamp Bars are removed. When all of the accessible holes were used, the Clamp Bars were removed one pair at a time and all of the newly accessible holes were used to locate spot welds before the subsequent pairs of Clamp Bars were removed. When all of the spot welds had been completed, the Weld Fixture was completely disassembled.

Following spot welding, all of the welds were deburred. The particular components fabricated in this task had a width at the wing root of approximately .830" for the .016" thick Wings, and a width of .845" - .870" for the .012" thick Wings as compared to the .754" reference dimension on Drawing No. TCW00041.

After welding, the Wing Assemblies were machined to the proper final shape per Drawing No. TCW00041. This was done by clamping the Flex-wing in the welded area adjacent to where the finished edge would be using a special fixture and milling away the excess material. A radius was hand filed on each of the four corners of the Wings per print.

The .012" thick Flex-wing Assemblies (S/N's 4 - 6) showed no signs of incomplete welds after the final machining was completed. However, the .016" thick Flex-wing Assemblies (S/N's 1 -3) did show some signs of incomplete welds, particularly in the outer rows of welds. These incomplete welds were apparently caused by failing to properly clamp the Wing Halves together. Serial No. 1 also showed some incomplete welds in the inner rows. This was most likely due to the fact that the two outer rows of welds were not spot welded to assist in holding the Wing Halves together until some of the Clamp Bars on the Welding Fixture had already been removed on this particular Serial number. All of the components with incomplete welds were returned to Unitek - Miyachi to have the necessary areas re-welded. There were adequate welds in place to hold the Wing Halves in the proper pre-stressed condition for re-welding even though the

2.4 Flex-Wing Assembly (continued)

parts had already been trimmed to size. A tabulation of the incomplete welds for each Serial Number is given in Appendix E.

3.0 Conclusion and Recommendations

The effort expended in this task has demonstrated the producibility of the TACAWS Flex-Wings. Flex-Wings of equal or superior quality to those produced during this task may now be produced in relatively short order since problems in locating the proper Resistance Spot Welding Equipment and developing the proper Spot Welding fixtures and procedures have been solved. The following recommendations are given in consideration of future Flex-Wing fabrication:

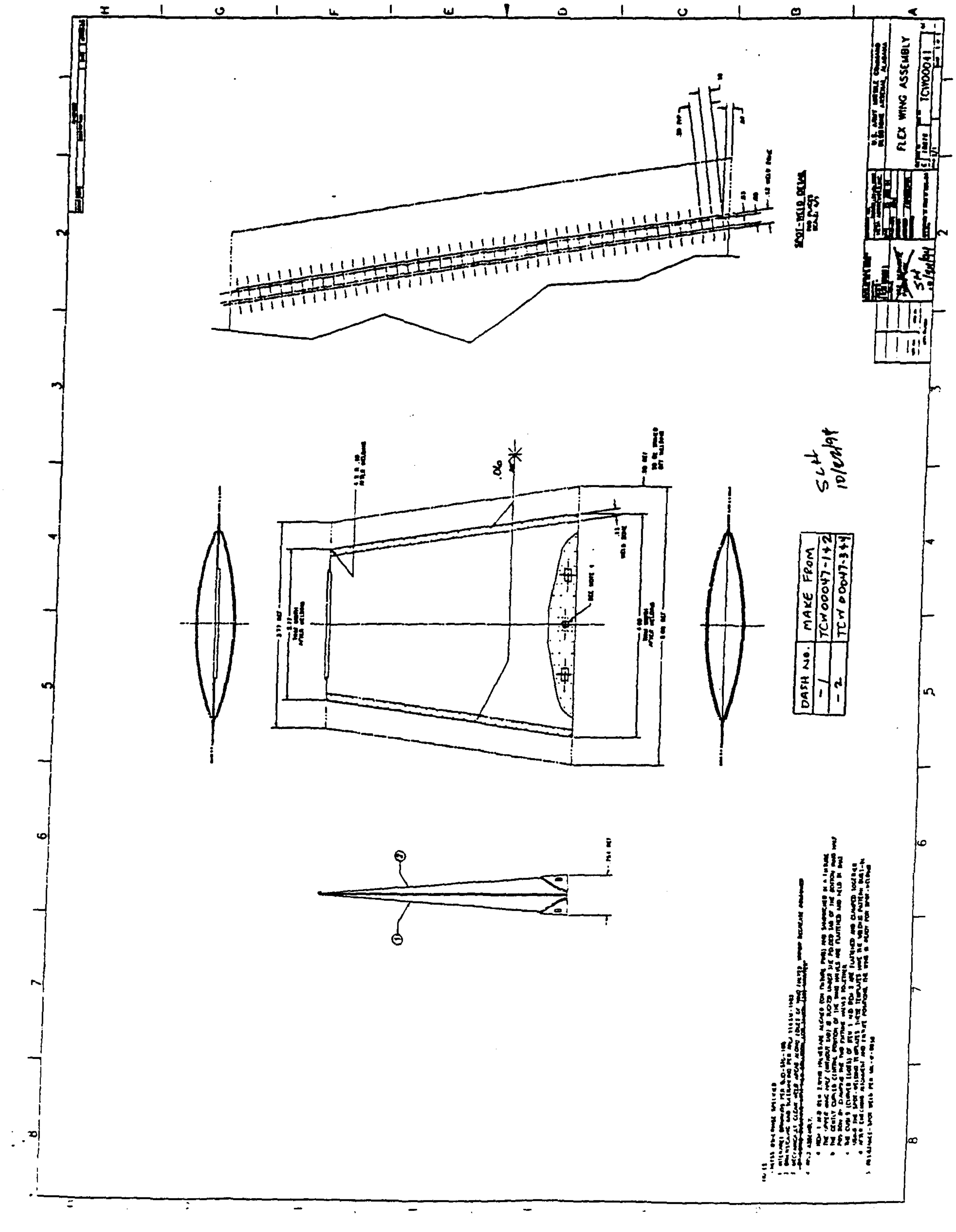
- Regardless of quantity to be produced, the type of Resistance Spot Welding equipment used in this task should be purchased. The cost of the equipment used in this task is less than $7,000. For higher quantity production, better Weld Heads and monitoring systems could be purchased for less than an additional $6000 to optimize and control the welding process. Optimized weld schedules for higher strength and improved appearance could be developed given the proper accessibility to the required welding equipment

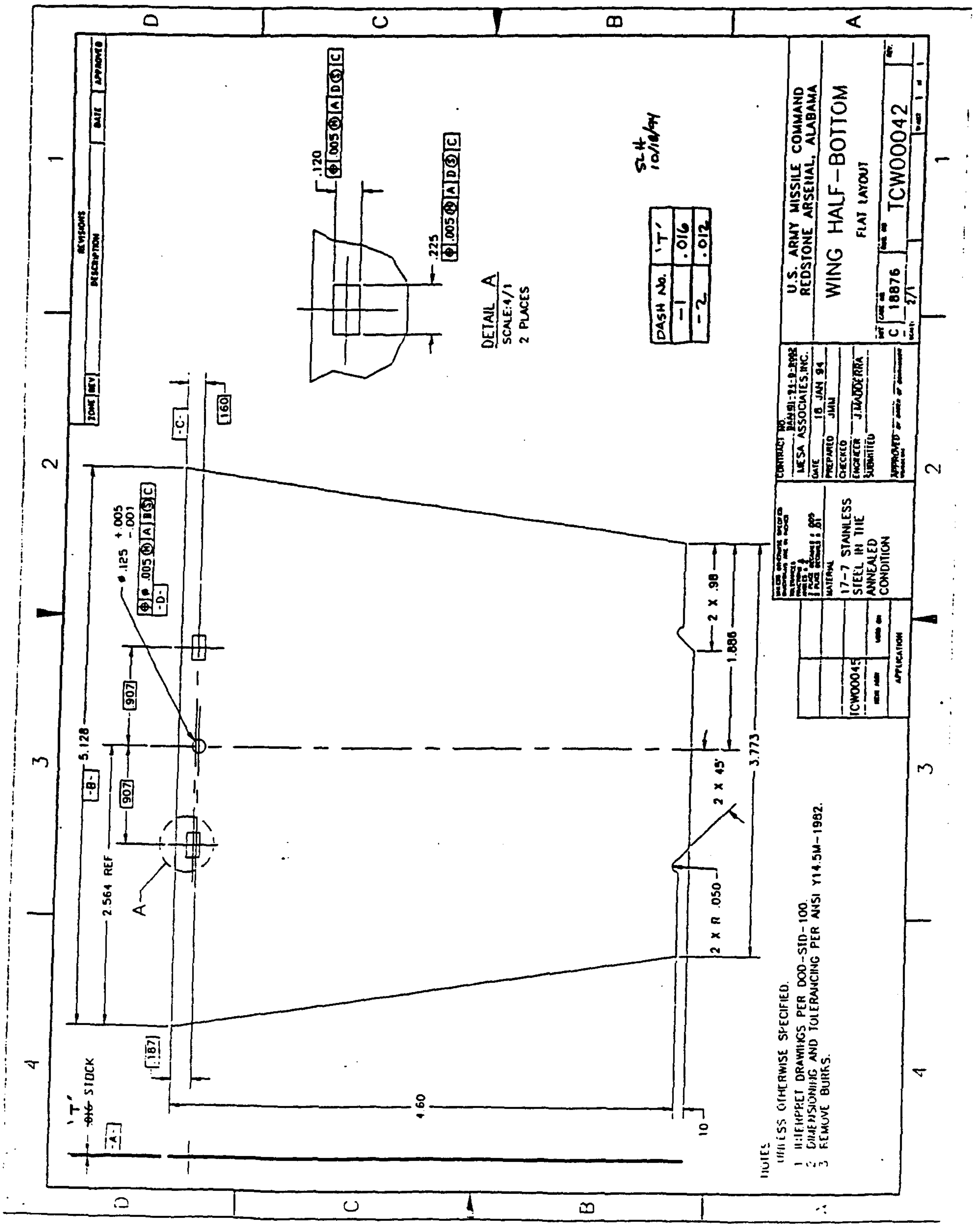
- Clamping of the Wing Halves during welding needs improvement. This can be easily accomplished with the existing Fixture for producing low quantities. The Weld Fixture should be redesigned for quick assembly and disassembly for higher quantities.

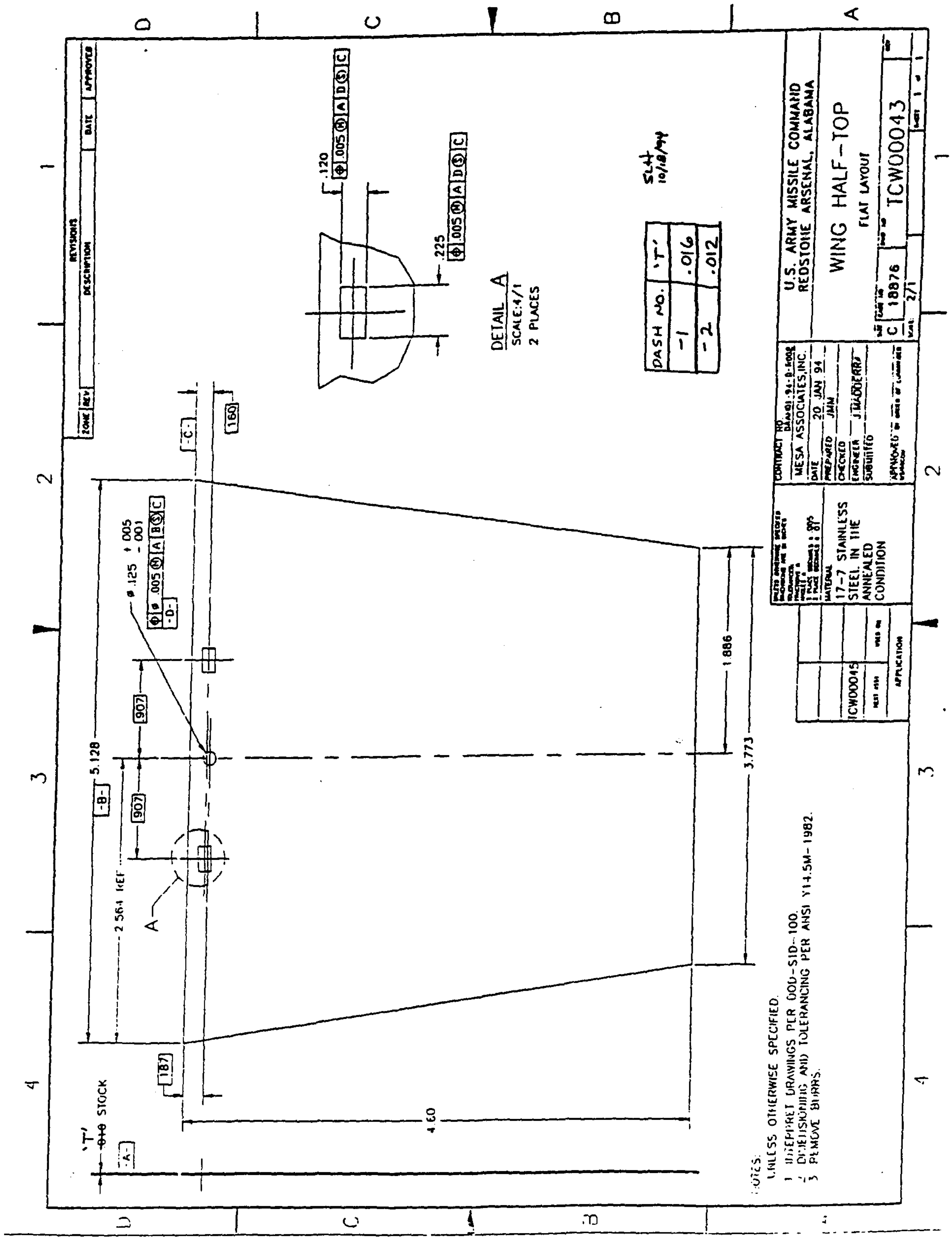
- The method of forming the Wing Halves used in this task is probably adequate for prototype quantities. Consideration should be given to relaxing tolerances to reduce production costs. In high quantity production, the parts should probably be stamped, requiring expensive tooling.

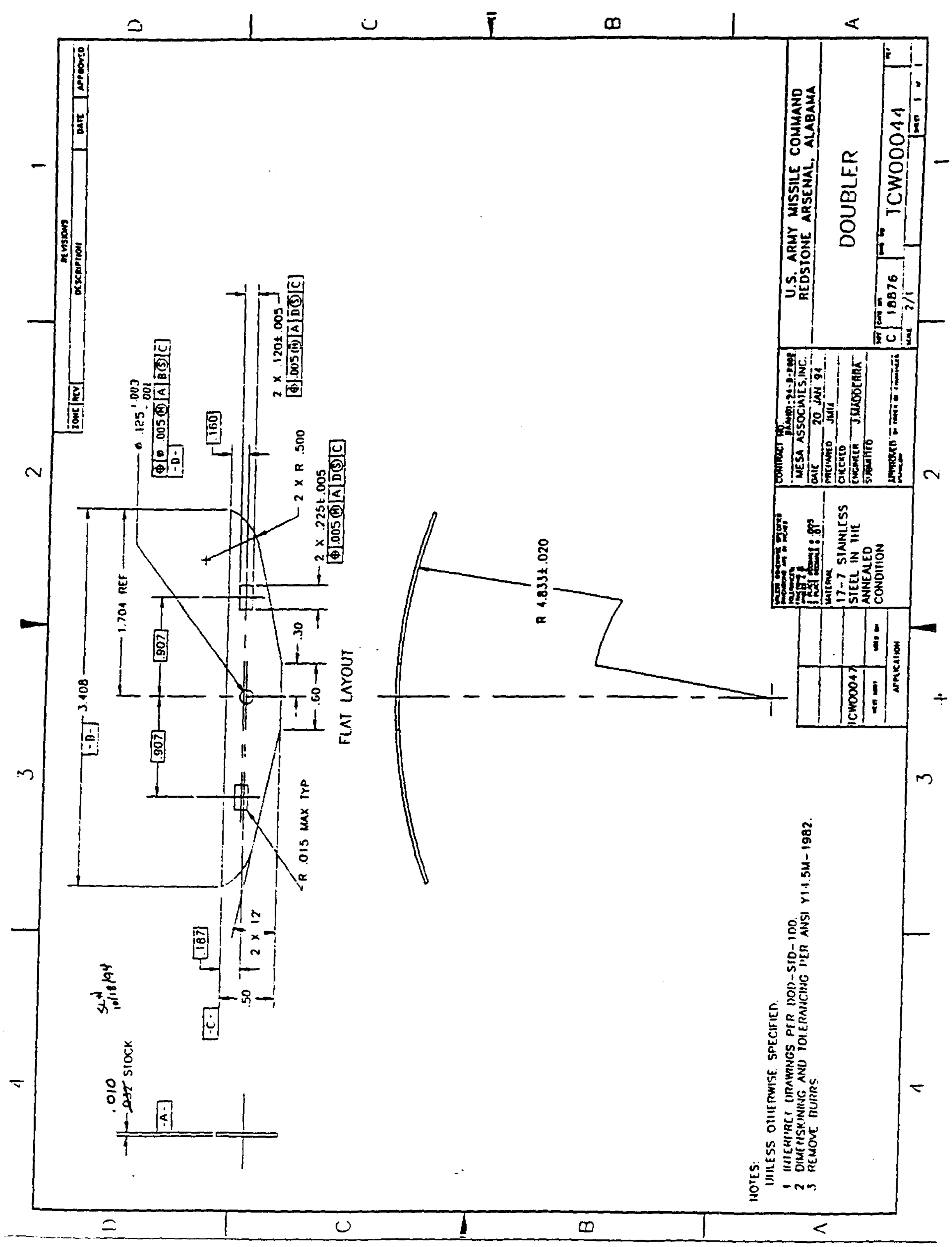
Appendix A

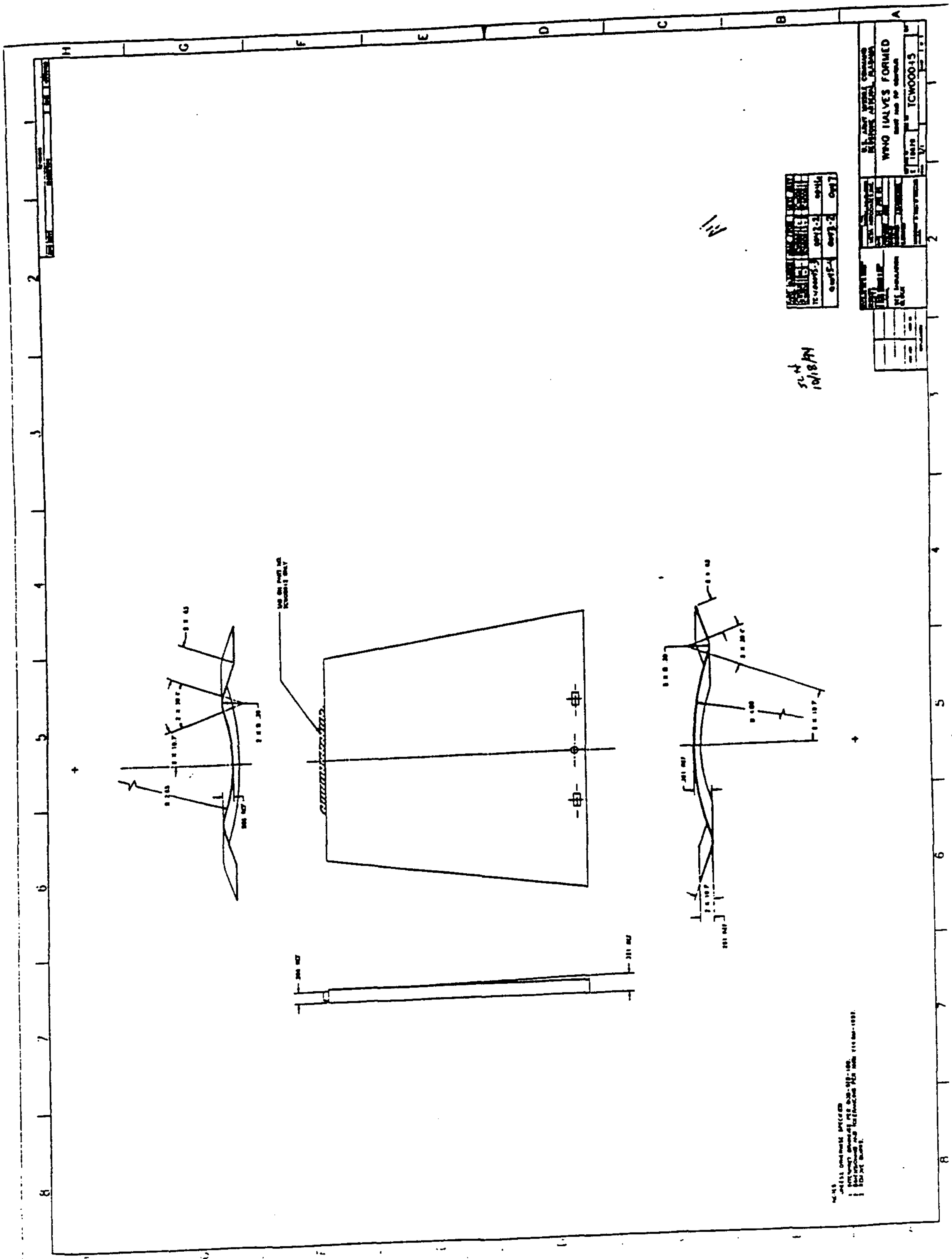
Annotated Drawings

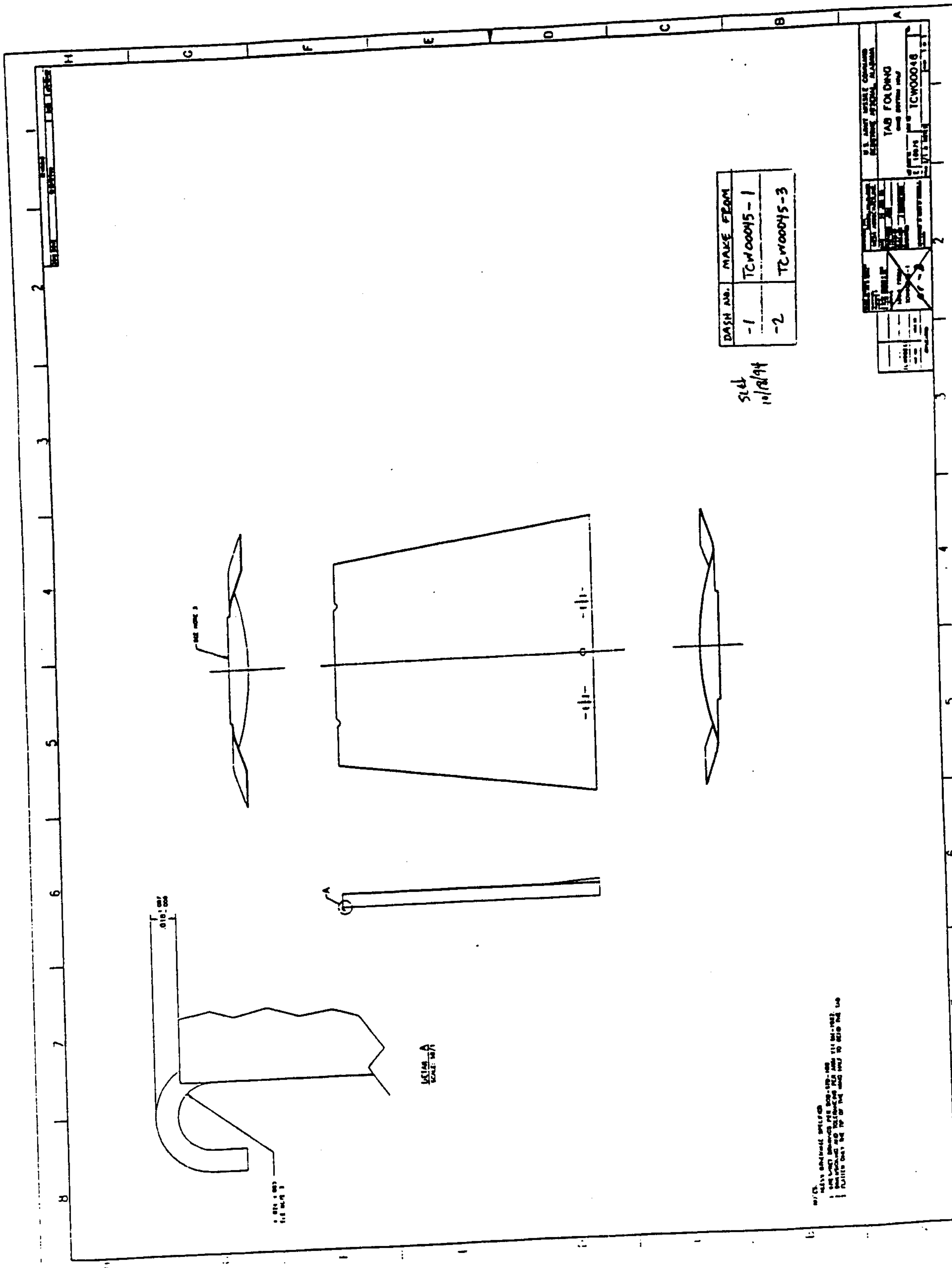

DASH NO.
MAKE FROM
-1
TCW00047-142
-2
TCW00047-344
SPOT-WELD DETAIL
FLEX WING ASSEMBLY
TCW00041

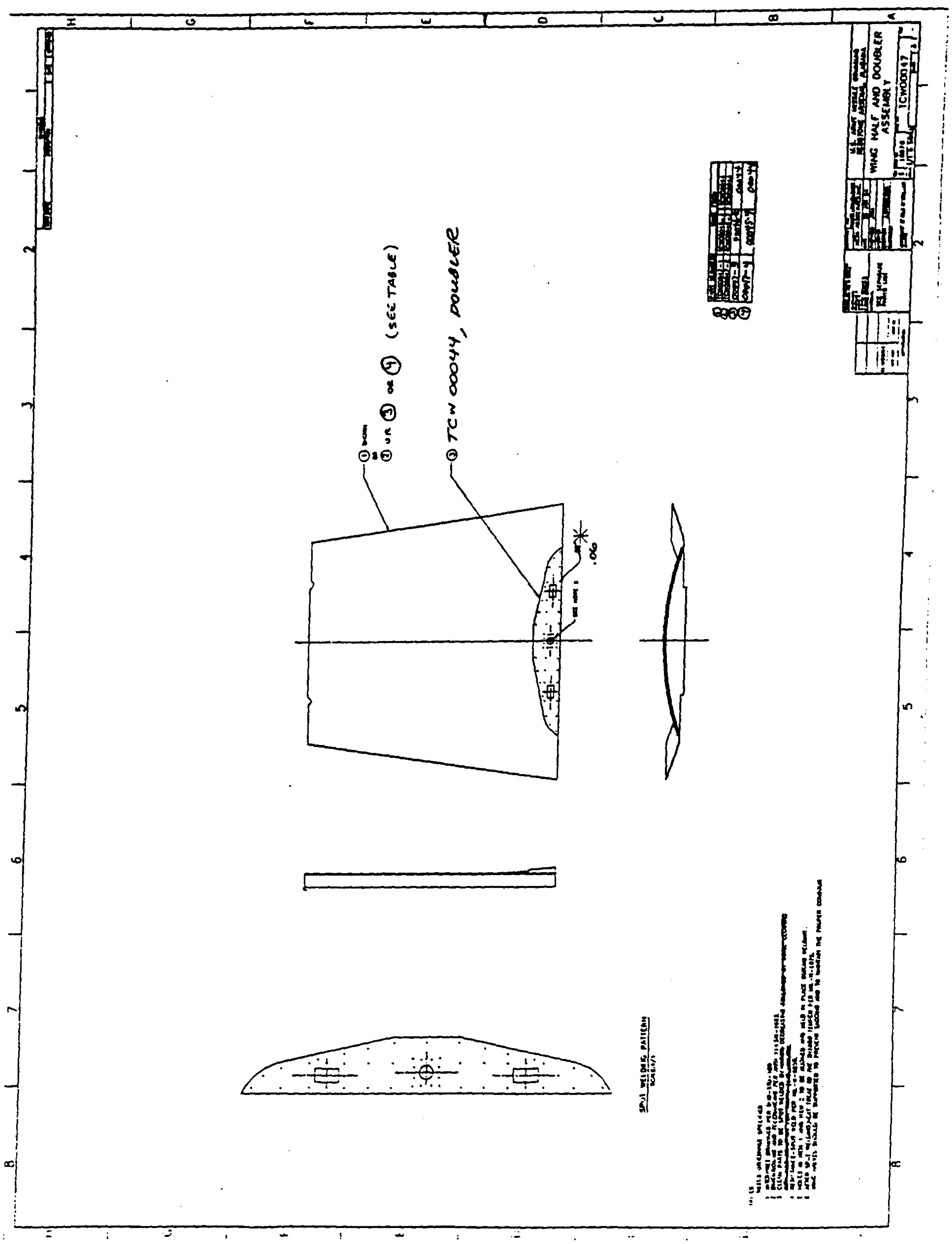

U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
WING HALF-BOTTOM
FLAT LAYOUT
TCW00042
C 18876
MESA ASSOCIATES, INC.
18 JAN 94
J.MADDERRA
17-7 STAINLESS STEEL IN THE ANNEALED CONDITION
TCW00045
APPLICATION
REVISIONS
DETAIL A
SCALE:4/1
2 PLACES
DASH No. 'T'
— 1 .016
— 2 .012
NOTES
UNLESS OTHERWISE SPECIFIED.
1 INTERPRET DRAWINGS PER DOD-STD-100.
2 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3 REMOVE BURRS.
'T' STOCK
5.128
2.564 REF
.907
.907
1.886
3.773
4.60
2 X .98
2 X 45°
2 X R .050
.187
.160
.10
.120
.225
⌀.125 +.005 -.001
-A-
-B-
-C-
-D-
A


REVISIONS
ZONE REV DESCRIPTION DATE APPROVED
DETAIL A
SCALE:4/1
2 PLACES
.120
.225
DASH NO. 'T'
-1 .016
-2 .012
5.128
2.564 REF
.907
.907
1.886
3.773
4.60
.187
.160
STOCK
-A-
-B-
-C-
-D-
A
17-7 STAINLESS STEEL IN THE ANNEALED CONDITION
TCW00045
APPLICATION
MESA ASSOCIATES, INC.
DATE 20 JAN 94
U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
WING HALF-TOP
FLAT LAYOUT
C 18876
TCW00043
2/1
NOTES:
UNLESS OTHERWISE SPECIFIED.
1 INTERPRET DRAWINGS PER DOD-STD-100.
2 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3 REMOVE BURRS.

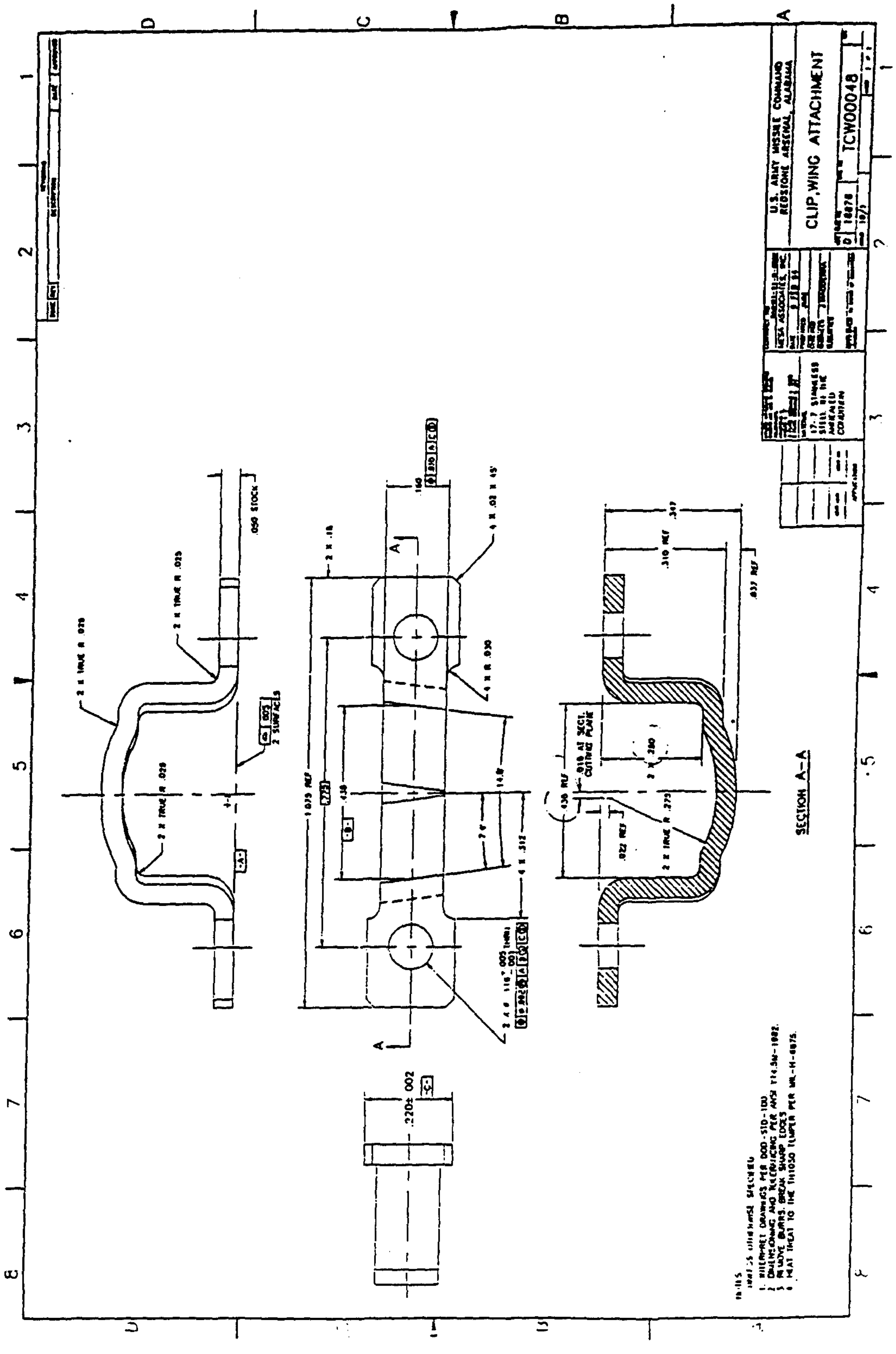

U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
DOUBLER
TCW00044
18876
MESA ASSOCIATES, INC.
20 JAN 94
J.MADDERRA
17-7 STAINLESS STEEL IN THE ANNEALED CONDITION
TCW00047
FLAT LAYOUT
R 4.833± .020
R .015 MAX TYP
2 X R .500
2 X .225± .005
2 X .120± .005
1.704 REF
3.408
.907
.907
NOTES:
UNLESS OTHERWISE SPECIFIED.
1 INTERPRET DRAWINGS PER DOD-STD-100.
2 DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
3 REMOVE BURRS.


WMO HALVES FORMED
TCW00045


DASH NO.
MAKE FROM
-1
TCW00045-1
-2
TCW00045-3
TAB FOLDING
TCW00048
DETAIL A



(SEE TABLE)
TCW 00044, DOUBLER
.060
SPOT WELDING PATTERN
WING HALF AND DOUBLER ASSEMBLY
TCW00047


U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
CLIP, WING ATTACHMENT
TCW00048
SECTION A-A
.050 STOCK
.220± .002
17-7 STAINLESS STEEL IN THE ANNEALED CONDITION

Appendix B

Nonconforming Material Reports for Formed Wing Halves

NONCONFORMING MATERIAL REPORT

CAMPBELL ENGINEERING

ITEM DESCRIPTION Wing Halves, Formed
NO. MICOM-424
JOB NO. 1050-001
PART NO. TCW 00045-2 REV. —
S/N
QUANTITY: REC. 3 INSP. 3 REJ. 3
RESPONSIBILITY: VENDOR X CEI
INSPECTOR 27 T. Ball DATE 12/7/94
VENDOR Fab Tech
DEVIATION: MAJOR MINOR

NONCONFORMANCE AND APPARENT CAUSE:

1.) Profile of parts checked against template shows a deviation of approximately .030.

DISPOSITION:

USE AS IS.

CORRECTIVE ACTION:

APPROVAL:

ENGINEERING Spencer L. Hudson DATE 12-9-94
QUALITY [signature] DATE 12-7-94
CUSTOMER DATE

ACTION COMPLETED:

INSPECTOR Tonya Ball DATE 12/7/94

CAMPBELL ENGINEERING

NONCONFORMING MATERIAL REPORT

ITEM DESCRIPTION Tab Folding	NO. MICOM-425
JOB NO. 1050-001	PART NO. TCW00046 REV. —
S/N	QUANTITY: REC. 3 INSP. 3 REJ. 3
RESPONSIBILITY: VENDOR X CEI	INSPECTOR R-7 T. Ball DATE 12/7/94
VENDOR Fab Tech	DEVIATION: MAJOR MINOR

NONCONFORMANCE AND APPARENT CAUSE:

1.) $.018^{+.007}_{-.000}$ ✓ .015-.030

DISPOSITION:

USE AS IS.

CORRECTIVE ACTION:

APPROVAL:

ENGINEERING	Spencer L. Hudson	DATE	12-9-94
QUALITY	[signature]	DATE	12-7-94
CUSTOMER		DATE	

ACTION COMPLETED:

INSPECTOR Vonya Ball DATE 12/7/94

CAMPBELL ENGINEERING

NONCONFORMING MATERIAL REPORT

ITEM DESCRIPTION Wing Halves Formed
NO. MICOM-426
JOB NO. 1050-001
PART NO. TCW-00045-1 REV. –
S/N
QUANTITY: REC. 5 INSP. 5 REJ. 5
RESPONSIBILITY: VENDOR X CEI
INSPECTOR R-7 T. Ball DATE
VENDOR Fab Tech
DEVIATION: MAJOR MINOR

NONCONFORMANCE AND APPARENT CAUSE:

1.) Profile of parts checked against template shows a deviation of approximately .030 .

DISPOSITION:

USE AS IS.

CORRECTIVE ACTION:

APPROVAL:

ENGINEERING Gerald L. Hodson DATE 12/9/94

QUALITY [signature] DATE 12-2-94

CUSTOMER DATE

ACTION COMPLETED:

INSPECTOR Vonya Ball DATE 12-7-94

NONCONFORMING MATERIAL REPORT

CAMPBELL ENGINEERING

ITEM DESCRIPTION	Tab Folding	NO.	MICOM-427
JOB NO.	1050-001	PART NO.	TCW00046-1 REV. –
S/N		QUANTITY:	REC. 5 INSP. 5 REJ. 5
RESPONSIBILITY:	VENDOR X CEI	INSPECTOR	P.7 T. Ball DATE 12/7/94
VENDOR	Fab Tech	DEVIATION:	MAJOR MINOR

NONCONFORMANCE AND APPARENT CAUSE:

1.) $.018 {}^{+.007}_{-.000}$ ✓ .015 -.030

DISPOSITION:

USE AS IS.

CORRECTIVE ACTION:

APPROVAL:

ENGINEERING	Spencer L. Hudson	DATE	12-9-94
QUALITY	[signature]	DATE	12-7-94
CUSTOMER		DATE	

ACTION COMPLETED:

INSPECTOR	Tonya Ball	DATE	12-7-94

CAMPBELL ENGINEERING

NONCONFORMING MATERIAL REPORT

ITEM DESCRIPTION Wing Halves Formed
NO. MICOM-428
JOB NO. 1050-001
PART NO. TCW00046-4 REV. —
S/N
QUANTITY: REC. 4 INSP. 4 REJ. 4
RESPONSIBILITY: VENDOR X CEI
INSPECTOR R.7 T. Ball DATE 12/7/94
VENDOR Fab Tech
DEVIATION: MAJOR MINOR

NONCONFORMANCE AND APPARENT CAUSE:

1.) Profile of parts checked against template shows a deviation of approximately .030.

DISPOSITION:

USE AS IS.

CORRECTIVE ACTION:

APPROVAL:

ENGINEERING Spencer L. Hudson DATE 12-9-94

QUALITY [signature] DATE 12-7-94

CUSTOMER DATE

ACTION COMPLETED:

INSPECTOR Tonya Ball DATE 12-7-94

Appendix C

Weld Schedules and Test Data

MODEL 250DP **UNITEK EQUIPMENT, INC.**

WELD EVALUATION REPORT

INDUSTRY: ELECTRONICS JOB: 9412-076
APPLICATION RATING: GOOD DATE: DEC. 12, 1994

APPLICATION: WELD .010" S.S TO .012" S.S. AND .016" S.S

CUSTOMER:	SPENCER HUDSON
COMPANY:	CAMPBELL ENGINEERING
ADDRESS:	3415 STANWOOD BOULEVARD HUNTSVILLE, AL 35811
TEL:	(205) 852-8720
FAX:	
REPRESENTATIVE:	ROTH COX ASSOC.
SALES ENGINEER:	ROCKY COX
TEL:	(704) 365-0898
LAB ENGINEER:	GRANT RING
APPROVED:	

WELDMENTS	**TOP**	**BOTTOM**
Material:	STAINLESS STEEL	STAINLESS STEEL
Size:	.010" THICK	.012" OR .016" THICK
Plating:	NONE	NONE
Insulation:	NONE	NONE

ELECTRODE CONFIGURATION

ELECTRODES	**TOP**	**BOTTOM**
Model No:	ES0450	ES0450
Material:	GLIDCOP	GLIDCOP
Face Size:	.062" DIA.	.062" DIA.
Shape:	STANDARD	STANDARD
Polarity:	POSITIVE	NEGATIVE
Gap:	N/A	N/A

WELD HEAD		**FORCE SETTING**		**CONNECTION**	
Model No:	HFT	Force (lbs):	19	Cable Size:	#2
Force Range:	3-25 LBS.	Force (Units):	8.5	Cable Length:	5'
Air/Foot:	N/A	**AIR PRESSURE (PSI)**			
Foot Switch:	N/A	Weld Head Up:	N/A		
Foot Pedal:	N/A	Weld Head Down:	N/A		

WELD SETTINGS	**PULSE 1**	**PULSE 2**
% Watt•Seconds:	40%	
Pulse Width:	MEDIUM	

COMMENTS: This evaluation was conducted under laboratory conditions. Suggested settings may vary with your manufacturing requirements. These settings should be used as a starting point in establishing an optimum weld schedule.

Expulsion can be reduced by reducing energy. This will affect pull strength. Both parts (.012" and .016") pulled in excess of 139 pounds, breaking material instead of weld.

UNITEK EQUIPMENT, INC.
1820 South Myrtle Avenue, Monrovia, CA 91017-7133 ● TEL: (818) 303-5676 ● FAX: (818) 358-8048

MODEL 250DP — *UNITEK EQUIPMENT, INC.*

WELD EVALUATION REPORT

INDUSTRY:ELECTRONICS — JOB:9412-099.1

APPLICATION RATING:GOOD — DATE:DEC. 21, 1994

APPLICATION: WELD .016 THICK HEAT TREATED S.S. TO SAME

CUSTOMER: SPENCER HUDSON
COMPANY: CAMPBELL ENGINEERING
ADDRESS: 3415 STANWOOD BOULEVARD
HUNTSVILLE, AL 35811

TEL: (205) 852-8720
FAX:

REPRESENTATIVE: ROTH COX ASSOC.
SALES ENGINEER: ROCKY COX
TEL: (704) 365-0898

LAB ENGINEER: GRANT RING
APPROVED:

Customer in facility 12/20 → 12/21 (Hand carried) samples back.

WELDMENTS	**TOP**	**BOTTOM**
Material:	STAINLESS STEEL	STAINLESS STEEL
Size:	.016" THICK	.016" THICK
Plating:	NONE	NONE
Insulation:	NONE	NONE

ELECTRODE CONFIGURATION

ELECTRODES	**TOP**	**BOTTOM**
Model No:	ES0450	ES0450
Material:	GLIDCOP	GLIDCOP
Face Size:	.062" DIA.	.062" DIA.
Shape:	STANDARD	STANDARD
Polarity:	POSITIVE	NEGATIVE
Gap:	N/A	N/A

WELD HEAD		**FORCE SETTING**		**CONNECTION**	
Model No:	HFT	Force (lbs):	17.5	Cable Size:	#2
Force Range:	3-25 LBS.	Force (Units):	8.5	Cable Length:	5'
Air/Foot:	N/A	**AIR PRESSURE (PSI)**			
Foot Switch:	N/A	Weld Head Up:	N/A		
Foot Pedal:	N/A	Weld Head Down:	N/A		

WELD SETTINGS	**PULSE 1**	**PULSE 2**
% Watt•Seconds:	35%	
Pulse Width:	MEDIUM	

COMMENTS: This evaluation was conducted under laboratory conditions. Suggested settings may vary with your manufacturing requirements. These settings should be used as a starting point in establishing an optimum weld schedule.

Pulled 124 lbs. on coupon at 40% energy. Reduced energy to 35% to reduce expulsion.

MODEL 250DP
WELD EVALUATION REPORT

UNITEK EQUIPMENT, INC.

INDUSTRY:ELECTRONICS — JOB:9412-099.2
APPLICATION RATING:GOOD — DATE:DEC. 21, 1994
APPLICATION: WELD .012 THICK HEAT TREATED S.S. TO SAME

CUSTOMER:	SPENCER HUDSON
COMPANY:	CAMPBELL ENGINEERING
ADDRESS:	3415 STANWOOD BOULEVARD HUNTSVILLE, AL 35811
TEL:	(205) 852-8720
FAX:	
REPRESENTATIVE:	ROTH COX ASSOC.
SALES ENGINEER:	ROCKY COX
TEL:	(704) 365-0898
LAB ENGINEER:	GRANT RING
APPROVED:	

WELDMENTS	**TOP**	**BOTTOM**
Material:	STAINLESS STEEL	STAINLESS STEEL
Size:	.012" THICK	.012" THICK
Plating:	NONE	NONE
Insulation:	NONE	NONE

ELECTRODE CONFIGURATION

ELECTRODES	**TOP**	**BOTTOM**
Model No:	ES0450	ES0450
Material:	GLIDCOP	GLIDCOP
Face Size:	.062" DIA.	.062" DIA.
Shape:	STANDARD	STANDARD
Polarity:	POSITIVE	NEGATIVE
Gap:	N/A	N/A

WELD HEAD		**FORCE SETTING**		**CONNECTION**	
Model No:	HFT	Force (lbs):	17.5	Cable Size:	#2
Force Range:	3-25 LBS.	Force (Units):	8.5	Cable Length:	5'
Air/Foot:	N/A	**AIR PRESSURE (PSI)**			
Foot Switch:	N/A	Weld Head Up:	N/A		
Foot Pedal:	N/A	Weld Head Down:	N/A		

WELD SETTINGS	**PULSE 1**	**PULSE 2**
% Watt•Seconds:	25%	
Pulse Width:	MEDIUM	

COMMENTS: This evaluation was conducted under laboratory conditions. Suggested settings may vary with your manufacturing requirements. These settings should be used as a starting point in establishing an optimum weld schedule.

Pulled 124 lbs. on coupon at 25% energy.

METALTEST, INC.
1206 5th Avenue South
Kent, Washington 98032
Phone (206) 813-5970 Fax (206) 813-5971

CAMPBELL ENGINEERING, INC.
3415 STANWOOD BLVD
HUNTSVILLE
AL 35811

LAB 412346
PO# 10194
MATL
SPEC
SIZE

12/27/94

Identity			Load (lbs)
LOT #1	17-7 SS	#1	115
	.010 TO .012	#2	122
	COND A	#3	148
LOT #2	17-7 SS	#1	145
	.010 TO .016	#2	141
	COND A	#3	145
LOT #3	17-7 SS	#1	97
	.012 TO .012	#2	97
	TH1050		
LOT #4	17-7 SS	#1	137
	.016 TO .016	#2	167
	TH1050	#3	148

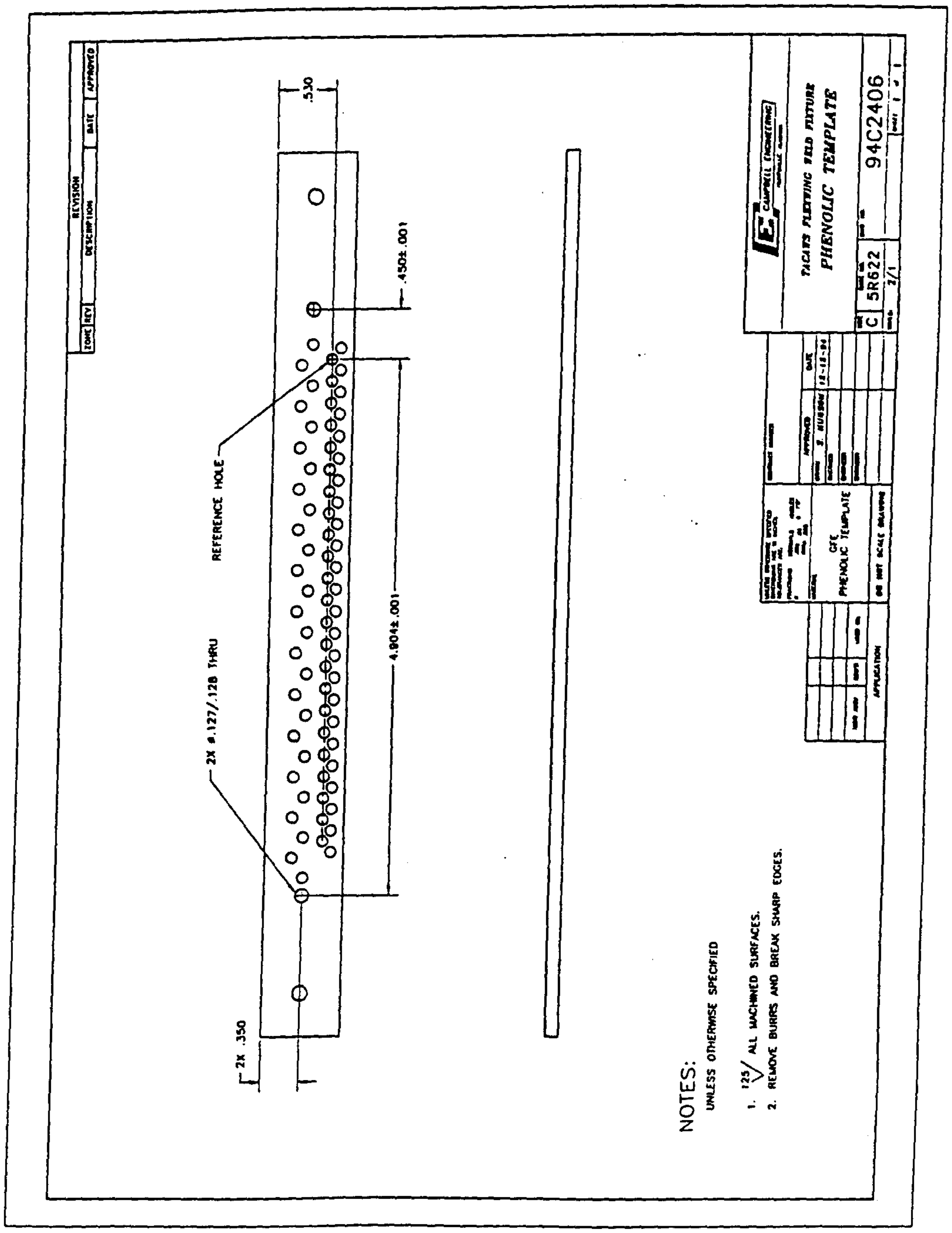
Respectfully,

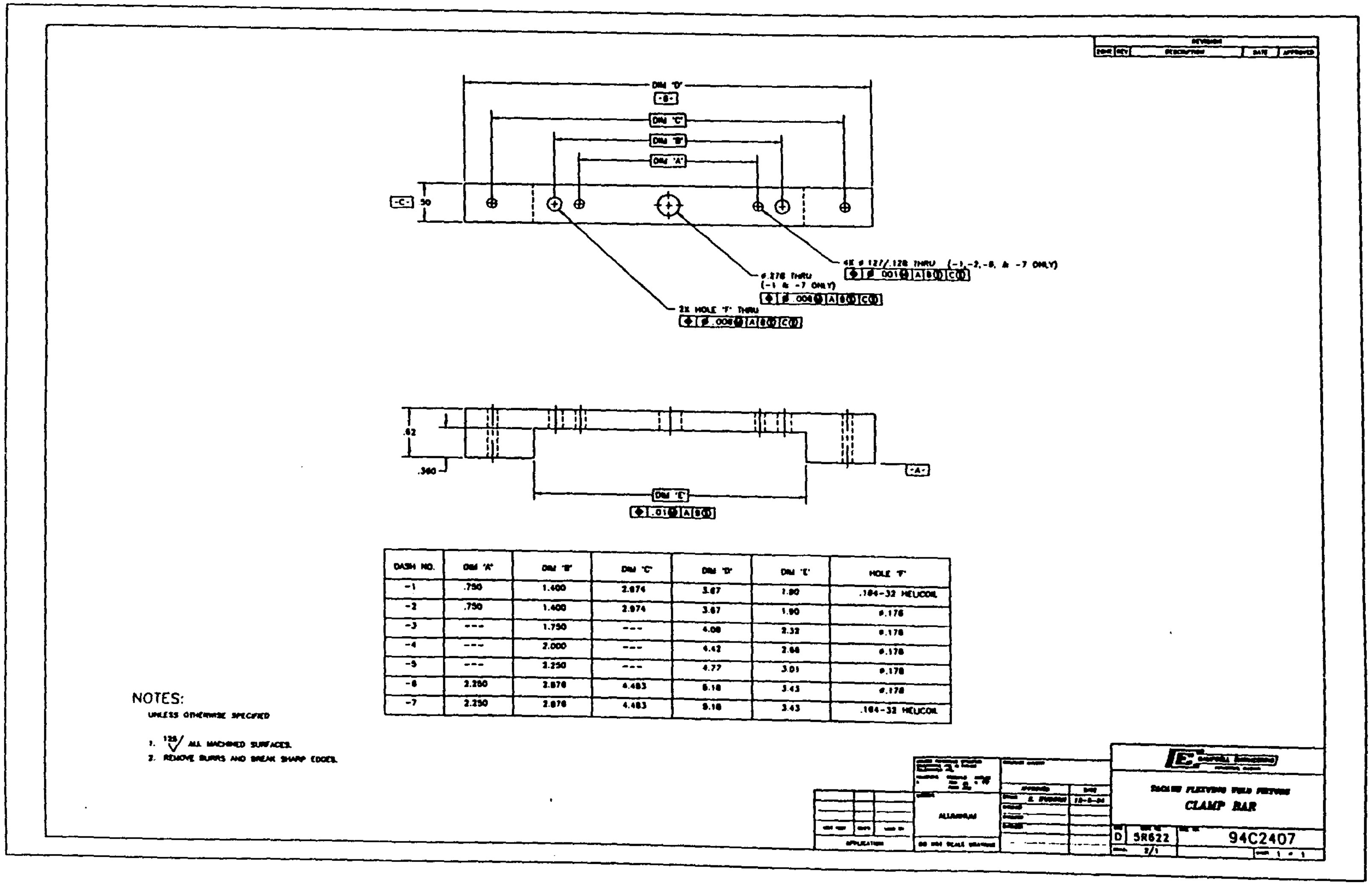
C. Blaine Maki

BLAINE MAKI
GENERAL MANAGER

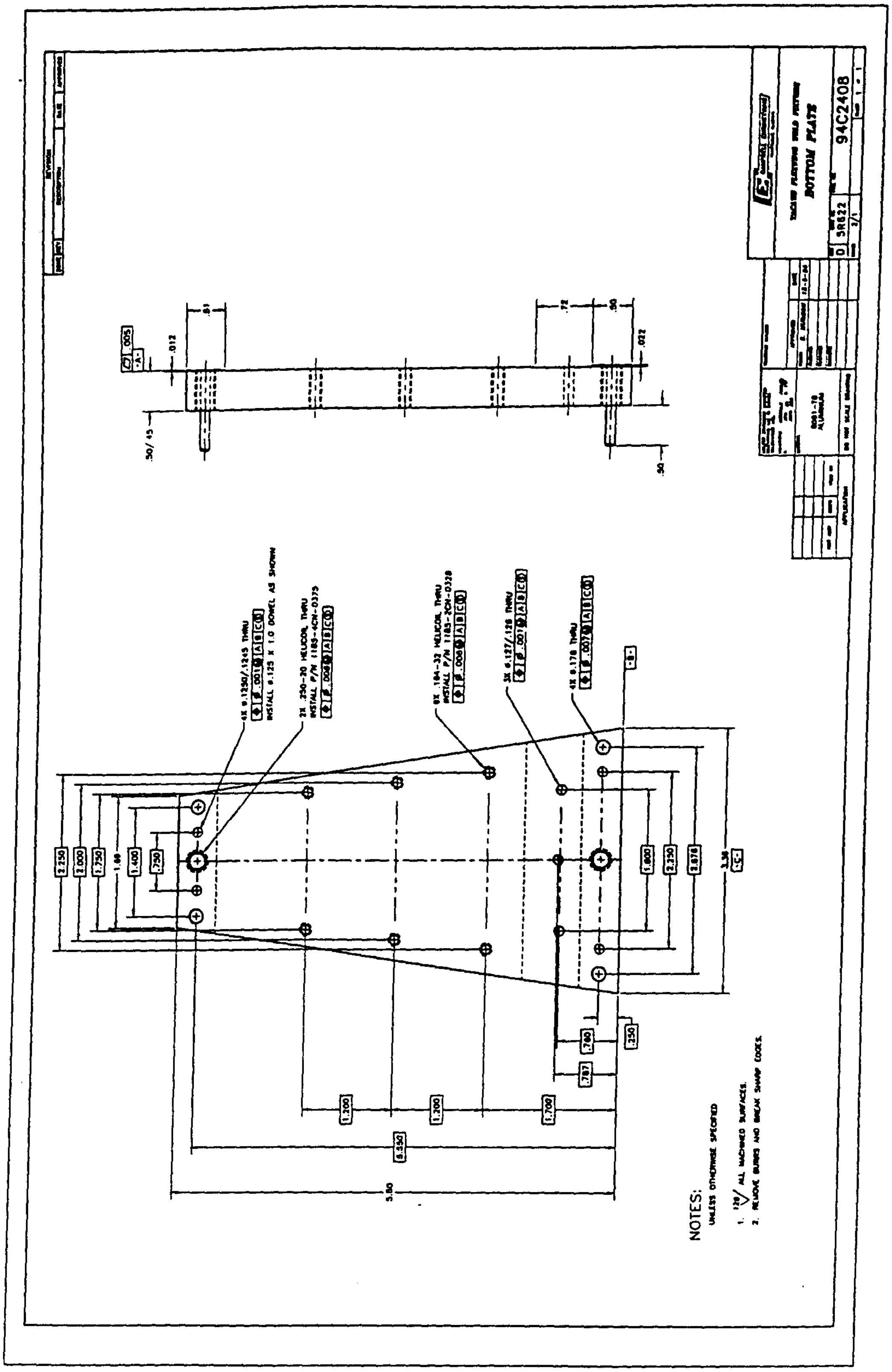
Appendix D

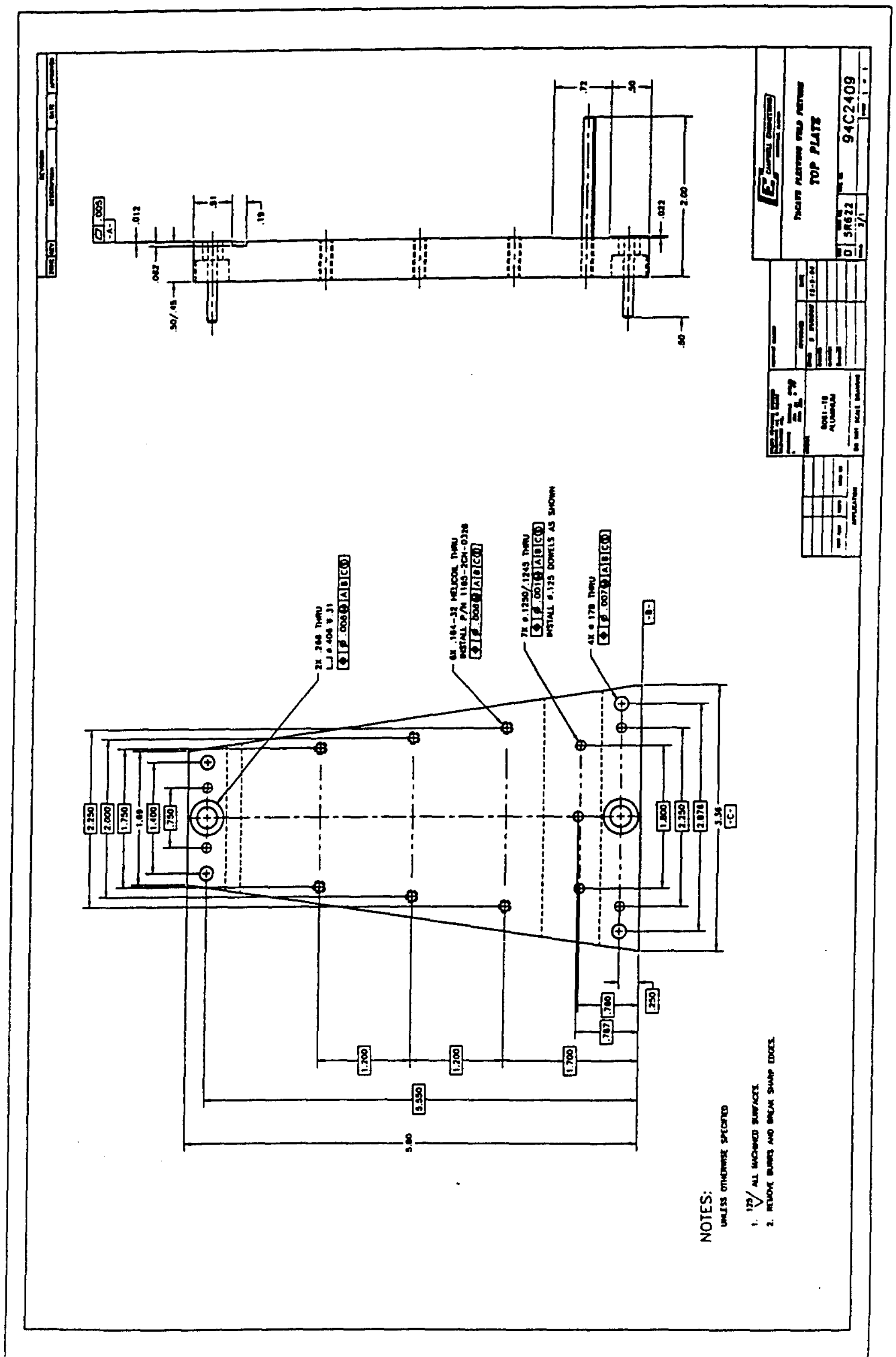
Weld Fixture Drawings


REVISION
ZONE
REV
DESCRIPTION
DATE
APPROVED
.530
.450±.001
REFERENCE HOLE
2X ⌀.127/.128 THRU
4.904±.001
2X .350
NOTES:
UNLESS OTHERWISE SPECIFIED
1. 125 ALL MACHINED SURFACES.
2. REMOVE BURRS AND BREAK SHARP EDGES.
CAMPBELL ENGINEERING
PHENOLIC TEMPLATE
C
5R622
94C2406
GFE
PHENOLIC TEMPLATE
DO NOT SCALE DRAWING
APPLICATION



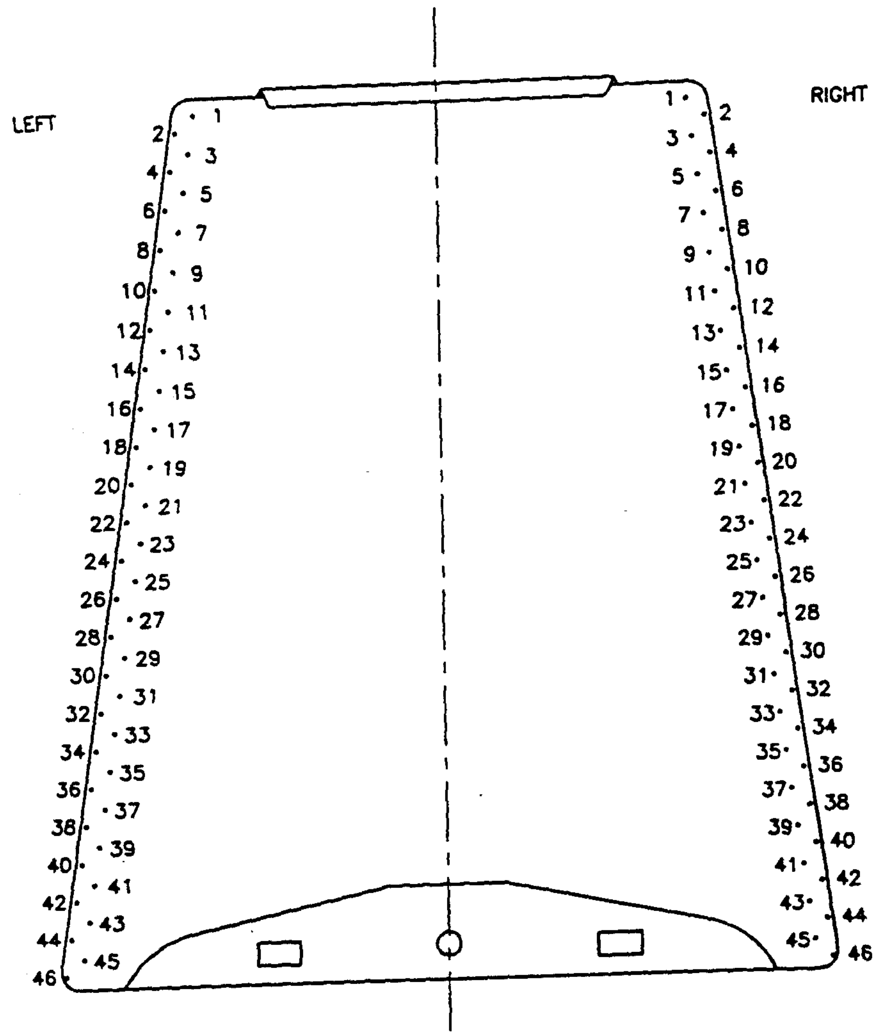
DASH NO.	DIM 'A'	DIM 'B'	DIM 'C'	DIM 'D'	DIM 'E'	HOLE 'F'
-1	.750	1.400	2.874	3.67	1.90	.164-32 HELICOIL
-2	.750	1.400	2.874	3.67	1.90	⌀.176
-3	---	1.750	---	4.08	2.32	⌀.178
-4	---	2.000	---	4.42	2.66	⌀.178
-5	---	2.250	---	4.77	3.01	⌀.178
-6	2.250	2.876	4.483	5.18	3.43	⌀.178
-7	2.250	2.876	4.483	5.18	3.43	.164-32 HELICOIL


NOTES:
UNLESS OTHERWISE SPECIFIED
2. REMOVE BURRS AND BREAK SHARP EDGES.
BOTTOM PLATE
94C2408


TOP PLATE
94C2409
NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL MACHINED SURFACES.
2. REMOVE BURRS AND BREAK SHARP EDGES.

Appendix E

Weld Rework Tabulation

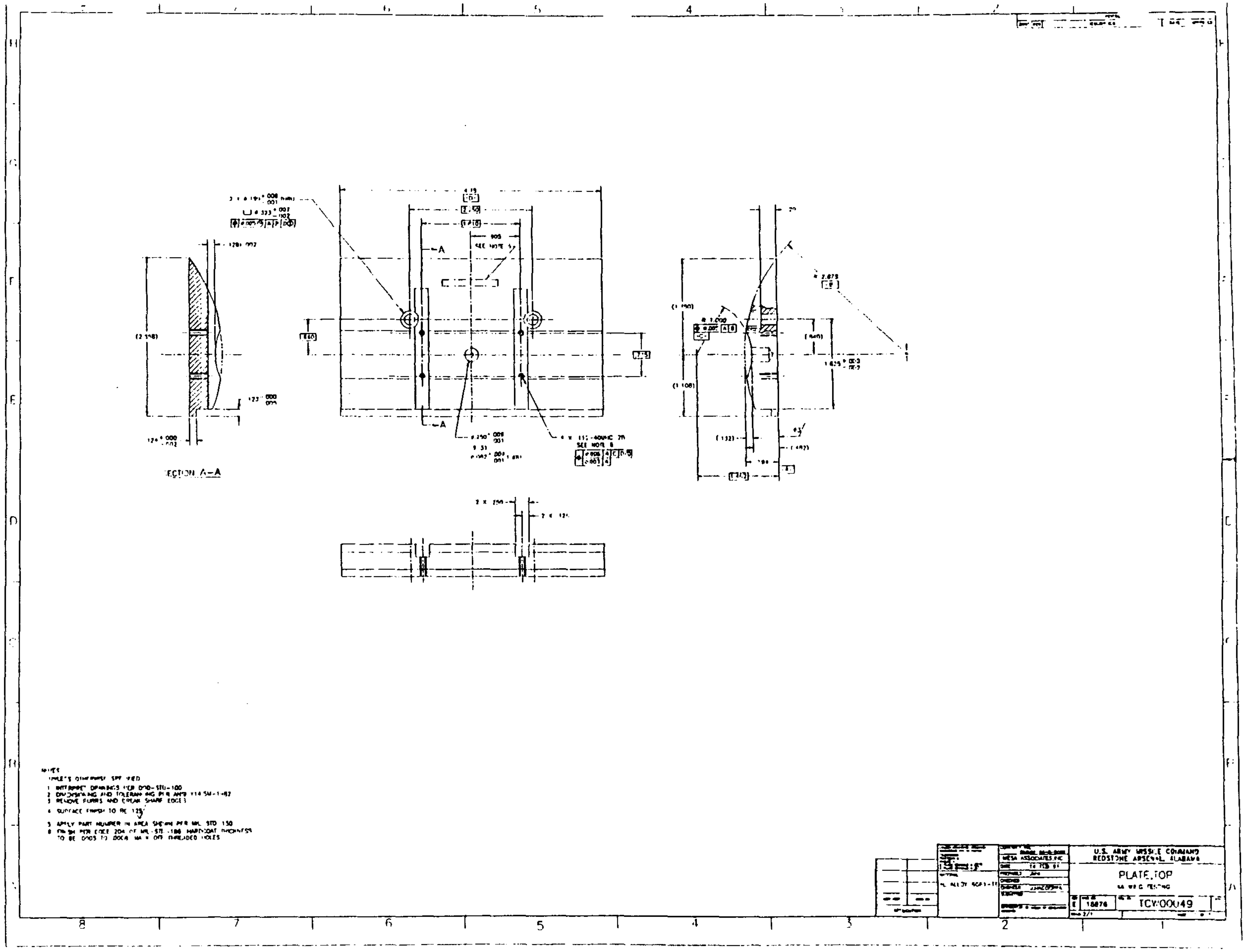


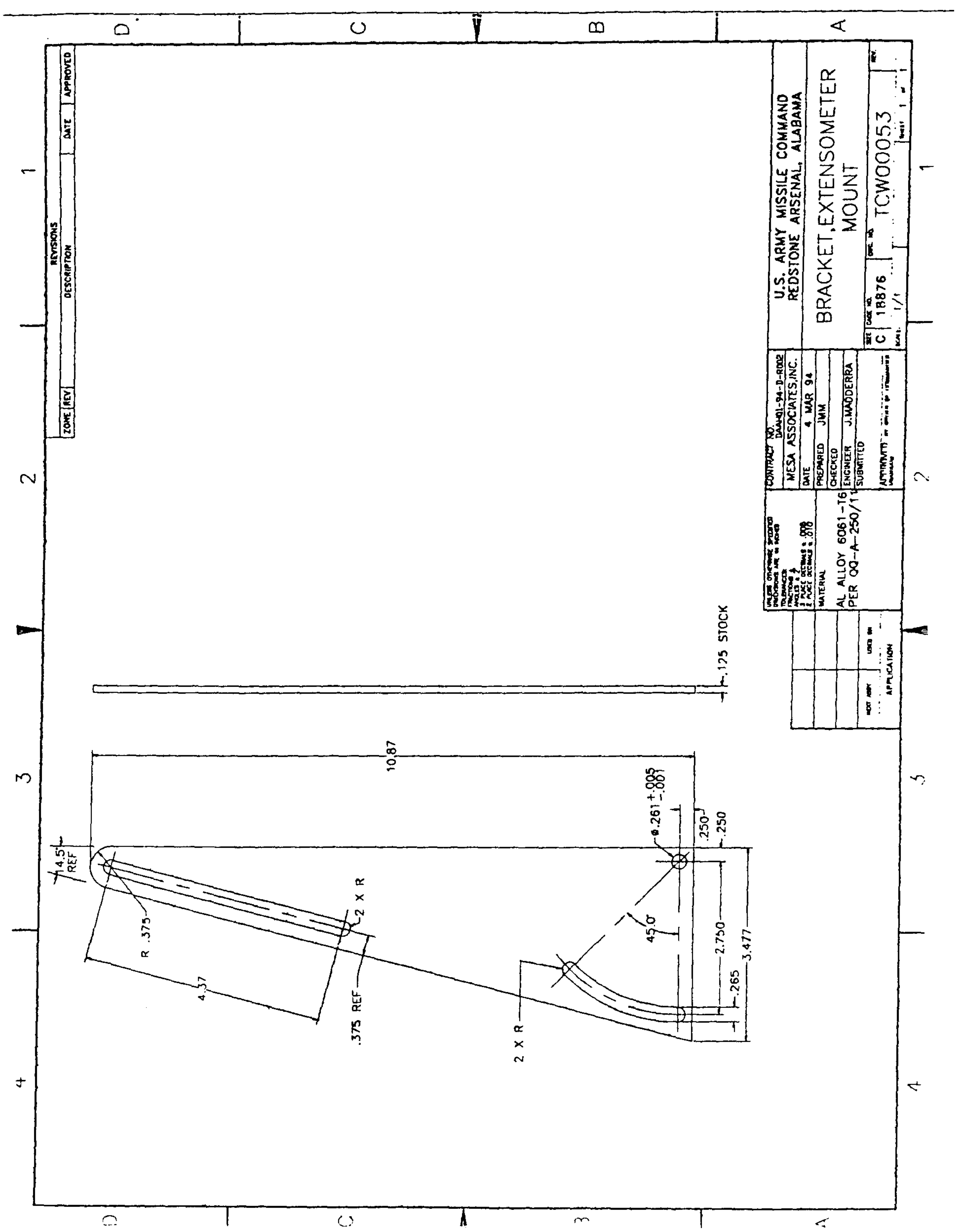
REWORKED SPOT WELDS

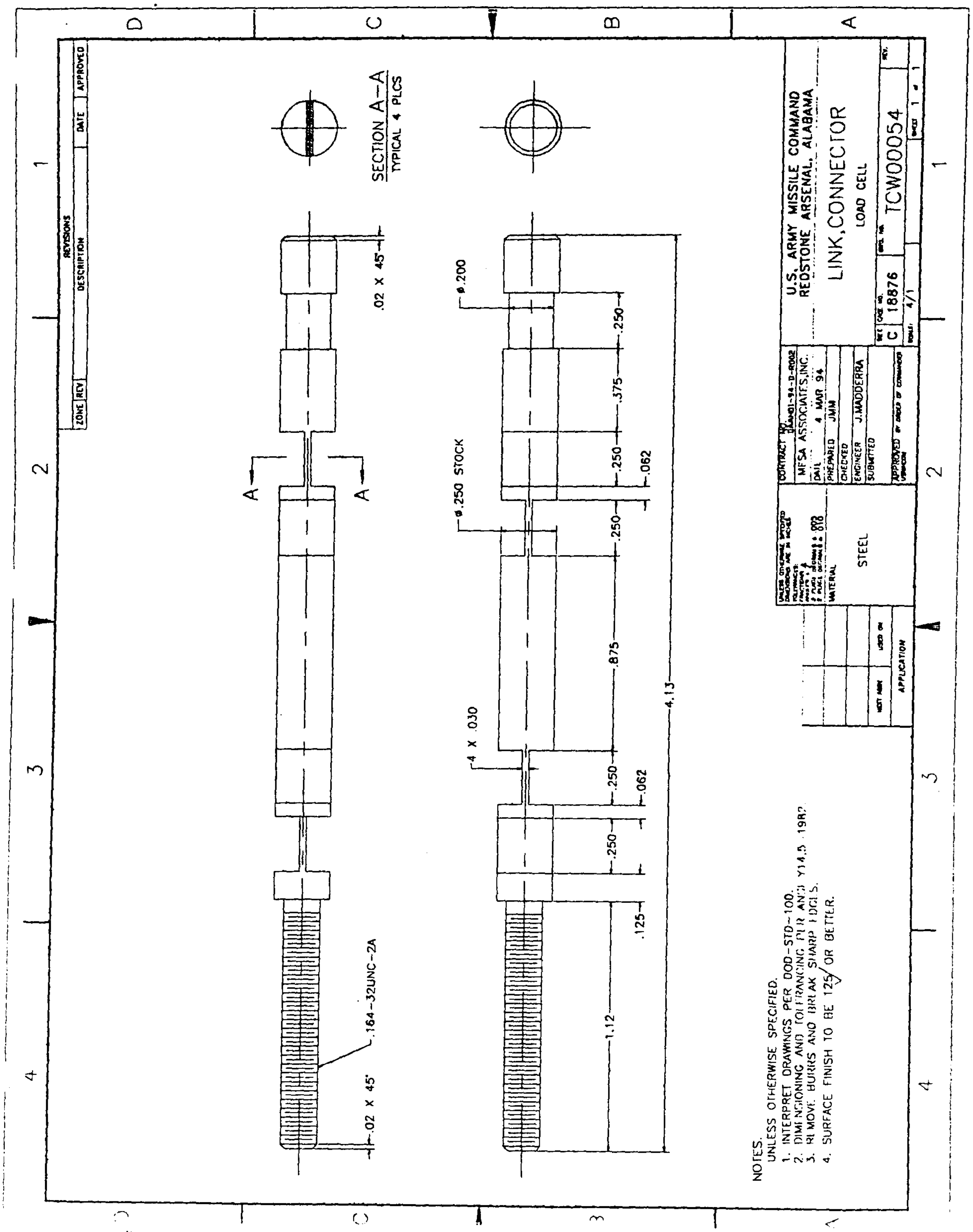
S/N	LEFT SIDE WELDS	RIGHT SIDE WELDS
1	ALL	ALL
2	6, 8, 12, 14, 24, 26, 30	2, 18
3	4, 6, 8, 10, 12, 14, 18, 28, 30, 34, 38, 44	NONE

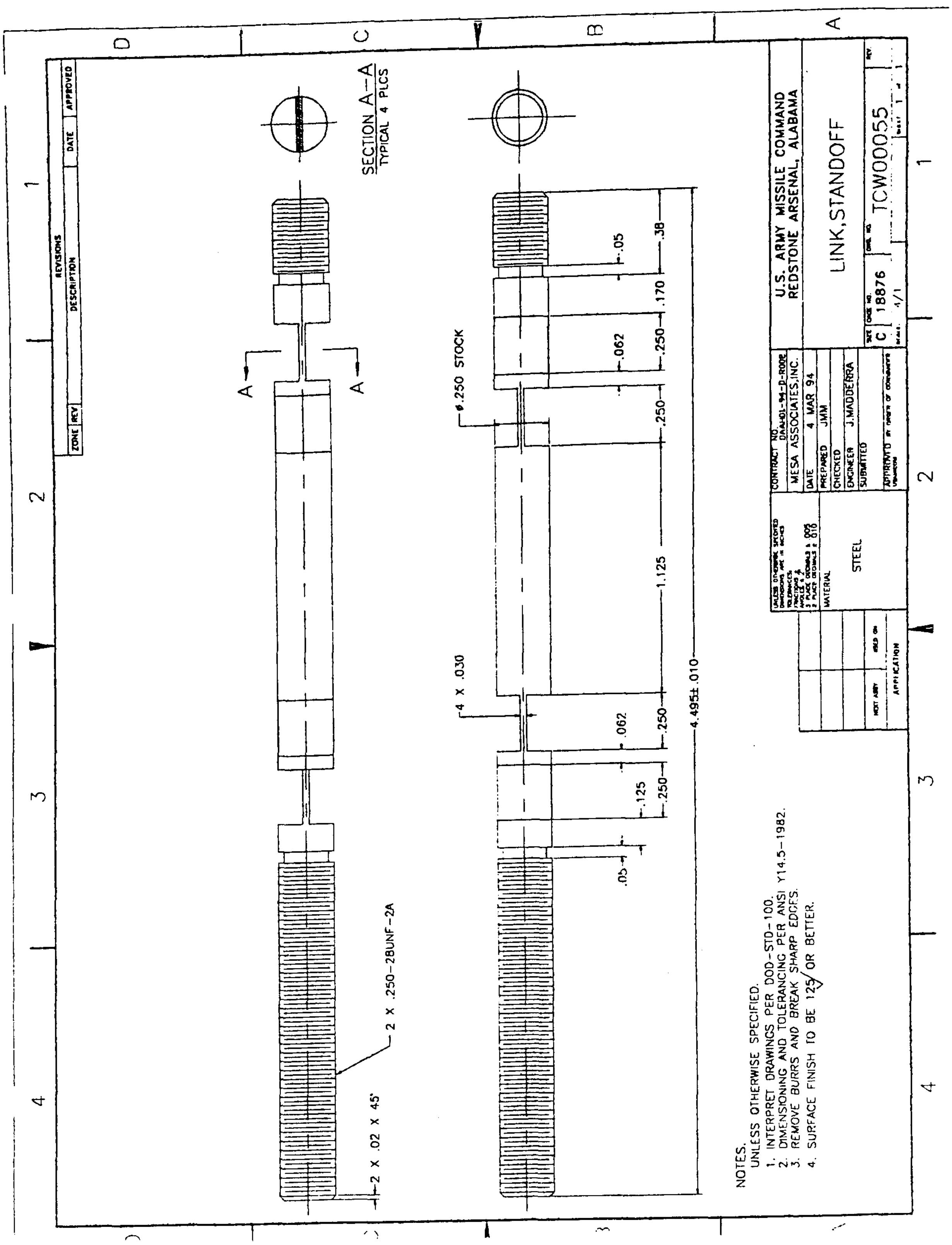
APPENDIX D
STATIC PRESSURE TEST FIXTURE PART DRAWINGS

APPENDIX D
STATIC PRESSURE TEST FIXTURE PART DRAWINGS

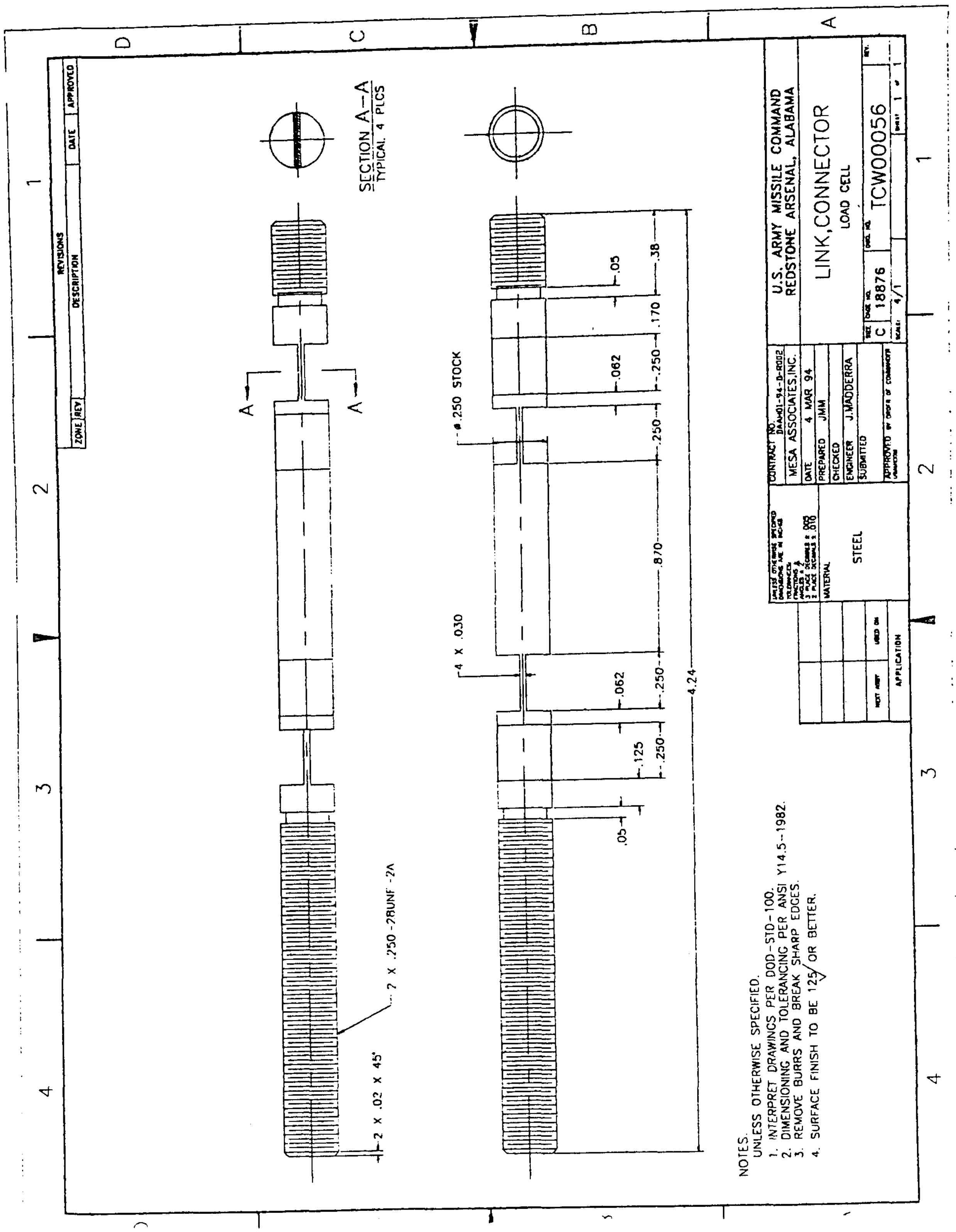



U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
BRACKET, EXTENSOMETER MOUNT
SIZE C
CAGE NO. 18876
DWG NO. TCW00053
SCALE 1/1
SHEET 1 of 1
CONTRACT NO. DAAH01-94-D-R002
MESA ASSOCIATES, INC.
DATE 4 MAR 94
PREPARED JMM
CHECKED
ENGINEER J.MADDERRA
SUBMITTED
MATERIAL
AL ALLOY 6061-T6
PER QQ-A-250/11
NEXT ASSY
USED ON
APPLICATION
REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
.125 STOCK
10.87
14.5°
REF
R .375
2 X R
4.37
.375 REF
2 X R
⌀.261 +.005 -.001
.250
.250
45°
2.750
3.477
.265

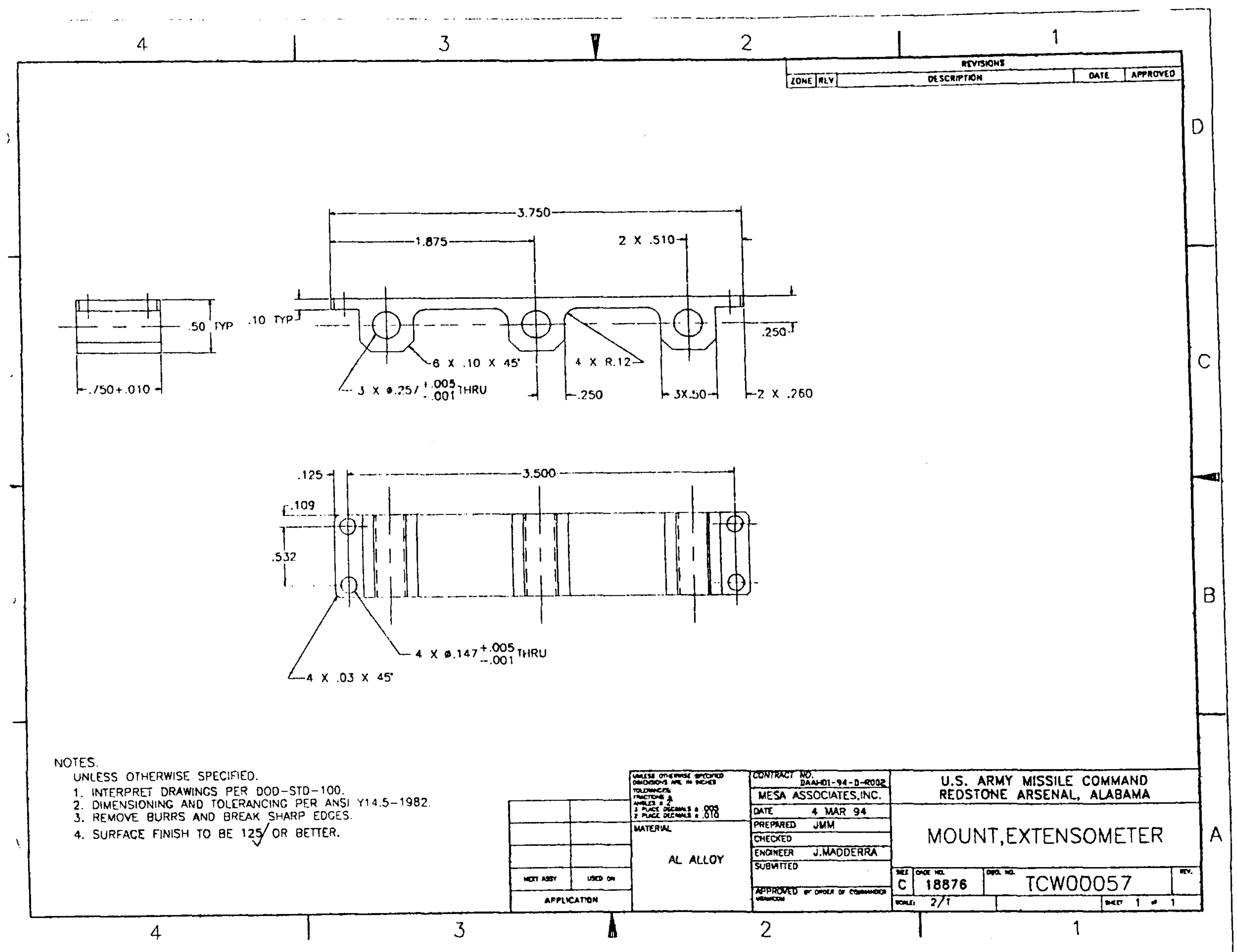

REVISIONS
ZONE REV DESCRIPTION DATE APPROVED
A
A
.02 X 45°
.164-32UNC-2A
.02 X 45°
SECTION A-A
TYPICAL 4 PLCS
4 X .030
ø.250 STOCK
ø.200
1.12
.125
.250
.250
.062
.875
.250
.250
.375
.250
.062
4.13
NOTES.
UNLESS OTHERWISE SPECIFIED.
1. INTERPRET DRAWINGS PER DOD-STD-100.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5-1982
3. REMOVE BURRS AND BREAK SHARP EDGES.
4. SURFACE FINISH TO BE 125 OR BETTER.
NEXT ASSY
USED ON
APPLICATION
MATERIAL
STEEL
CONTRACT NO.
DAAH01-94-D-R002
MFSA ASSOCIATES,INC.
DATE 4 MAR 94
PREPARED JMM
CHECKED
ENGINEER J.MADDERRA
SUBMITTED
APPROVED
U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
LINK,CONNECTOR
LOAD CELL
C
18876
TCW00054
SCALE 4/1
SHEET 1 of 1

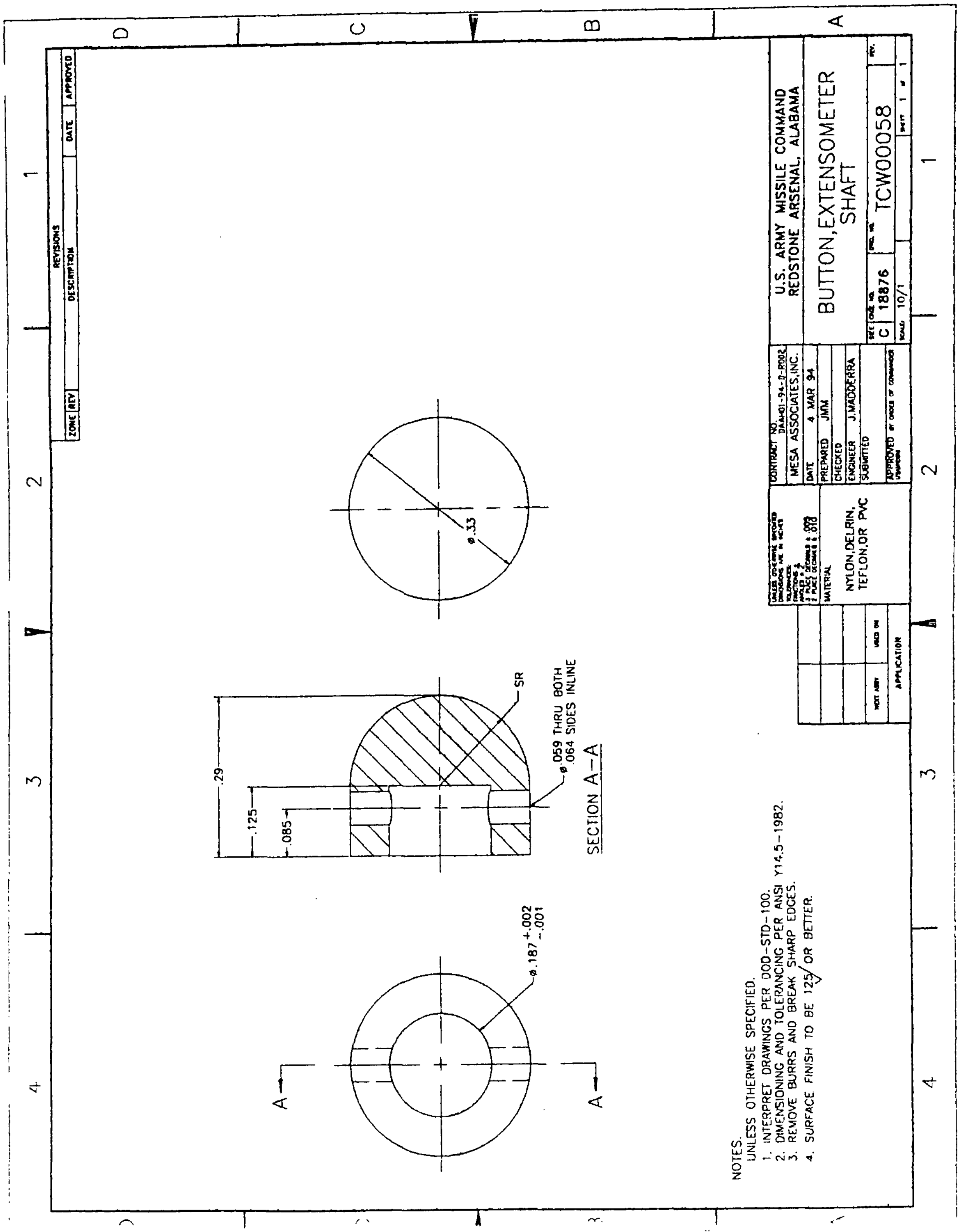


SECTION A–A
TYPICAL 4 PLCS
2 X .250-28UNF-2A
2 X .02 X 45°
ø.250 STOCK
4 X .030
.05
.38
.170
.062
.250
.250
1.125
.250
.062
.125
.250
.05
4.495±.010
NOTES.
UNLESS OTHERWISE SPECIFIED.
1. INTERPRET DRAWINGS PER DOD-STD-100.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5-1982.
3. REMOVE BURRS AND BREAK SHARP EDGES.
4. SURFACE FINISH TO BE 125 OR BETTER.
REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
CONTRACT NO.
DAAH01-94-D-R002
MESA ASSOCIATES, INC.
DATE 4 MAR 94
PREPARED JMM
CHECKED
ENGINEER J. MADDERRA
SUBMITTED
APPROVED
MATERIAL
STEEL
APPLICATION
U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
LINK, STANDOFF
C
18876
TCW00055
1/1



U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
LINK, CONNECTOR
LOAD CELL
C 18876
TCW00056
SCALE: 4/1
SHEET 1 of 1
CONTRACT NO. DAAH01-94-D-R002
MESA ASSOCIATES, INC.
DATE 4 MAR 94
PREPARED JMM
CHECKED
ENGINEER J. MADDERRA
SUBMITTED
APPROVED
MATERIAL
STEEL
NEXT ASSY
USED ON
APPLICATION
REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
SECTION A—A
TYPICAL 4 PLCS
A
⌀.250 STOCK
4 X .030
2 X .250-28UNF-2A
2 X .02 X 45°
.05
.38
.170
.250
.062
.250
.870
.250
.062
.125
.250
.05
4.24
NOTES:
UNLESS OTHERWISE SPECIFIED.
1. INTERPRET DRAWINGS PER DOD-STD-100.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5-1982.
3. REMOVE BURRS AND BREAK SHARP EDGES.
4. SURFACE FINISH TO BE 125 OR BETTER.


REVISIONS
ZONE
RLV
DESCRIPTION
DATE
APPROVED
3.750
1.875
2 X .510
.50 TYP
.10 TYP
.250
6 X .10 X 45°
4 X R.12
3 X ø.25 +.005 -.001 THRU
.250
3X.50
2 X .260
.750+.010
.125
3.500
.109
.532
4 X ø.147 +.005 -.001 THRU
4 X .03 X 45°
NOTES.
UNLESS OTHERWISE SPECIFIED.
1. INTERPRET DRAWINGS PER DOD-STD-100.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5-1982.
3. REMOVE BURRS AND BREAK SHARP EDGES.
4. SURFACE FINISH TO BE 125 OR BETTER.
NEXT ASSY
USED ON
APPLICATION
MATERIAL
AL ALLOY
CONTRACT NO.
DAAH01-94-D-R002
MESA ASSOCIATES,INC.
DATE 4 MAR 94
PREPARED JMM
CHECKED
ENGINEER J.MADDERRA
SUBMITTED
APPROVED
U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
MOUNT,EXTENSOMETER
C 18876
TCW00057
SCALE 2/1
SHEET 1 of 1


U.S. ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
BUTTON, EXTENSOMETER SHAFT
TCW00058
C 18876
SCALE 10/1
SHEET 1 of 1
CONTRACT NO. DAAH01-94-D-R002
MESA ASSOCIATES, INC.
DATE 4 MAR 94
PREPARED JMM
CHECKED
ENGINEER J.MADDERRA
SUBMITTED
APPROVED BY ORDER OF COMMANDER
MATERIAL
NYLON, DELRIN, TEFLON, OR PVC
NEXT ASSY
USED ON
APPLICATION
REVISIONS
ZONE
REV
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DEPARTMENT of DEFENSE

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30 November 2001

To: **Mr. Larry Downing**

Organization: DTIC
Office Phone:
FAX Number: (703) 767-9244

From: **Sharon Reinke, Navy Division, DFOISR/WHS/DOD**

Phone: (703) 697-2716
FAX: (703) 693-7341

Total Pages Transmitted (including cover sheet): 04

Comments: I am forwarding the FOIA request DTIC received, the DTIC forwarding letter, and a list of documents. The documents in the attached list have been released to a FOIA requester [under our case number 01-F-2458] and are, therefore, cleared for public release. If you have questions, give me a call.

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April 11, 2001

Defense Technical Information Center
Attn: Kelly Akers, FOIA Manager
8725 John J. Kingman Road Suite 0944
Fort Belvoir, VA 22060-6218

FOIA REQUEST

Dear Ms. Akers:

American Lawyer Media respectfully requests, under the Freedom of Information Act, a copy of each of the following records:

AD B253477, XV-8A Flexible Wing Aerial Utility Vehicle, by H. Kredit, January 1964, 144 pages

AD B252433, Pilot's Handbook for the Flexible Wing Aerial Utility Vehicle XV-8A, March 1964, 52 pp

AD B200629, Flex Wing Fabrication and Static Pressure Testing, by Larry D. Lucas. June 1995, 80 pages

AD B198352, Materials Analysis of Foreign Produced Flex Wings, by Albert Ingram, march 1995, 16 pp.

AD B131204, Active Flexible Wing Technology, by Gerald D. Miller, Feb. 1988, 256 pages

AD B130217, Producibility Analysis of the Alternative Antitank Airframe Configuration Flex Wing, June 1988, 112 pages

AD B126450, From Delta Glider to Airplane, June 1988, 5 pages

—AD ~~B~~803668, Sailwing Wind Tunnel Test Porgram, September 1966, 125 pages

AD 477 482, An Evaluation of Flex-Wing Aircraft in Support of Indigenous Forces Involved in Counterinsurgency Operations by R.A. Wise, Feb 1965, 74 pages

—AD 461202, XV-8A Flexible Wing Aerial Utility Vehicle, H. Kredit, Feb. 1965, 100 pages

—AD 460405, XV-8A Flexible Wing Aerial Utility Vehicle, Final Report, Feb. 1965, 113 pages

—AD 431128, Operational Demonstration and Evaluation of the Flexible Wing Precision Drop Glider in Thailand, by William R. Quinn, November 1963, 22 pages.

AD 430150, Comparative Evaluation of Republic Bikini Drone System, Final Report, 1943?

We agree to pay up to $200 for costs associated with this request. We are grateful for your kind assistance in this matter. Please contact me at 212-313-9067 if you have any questions relating to our request.

Sincerely,

Michael Ravnitzky
Editor

Encl 1